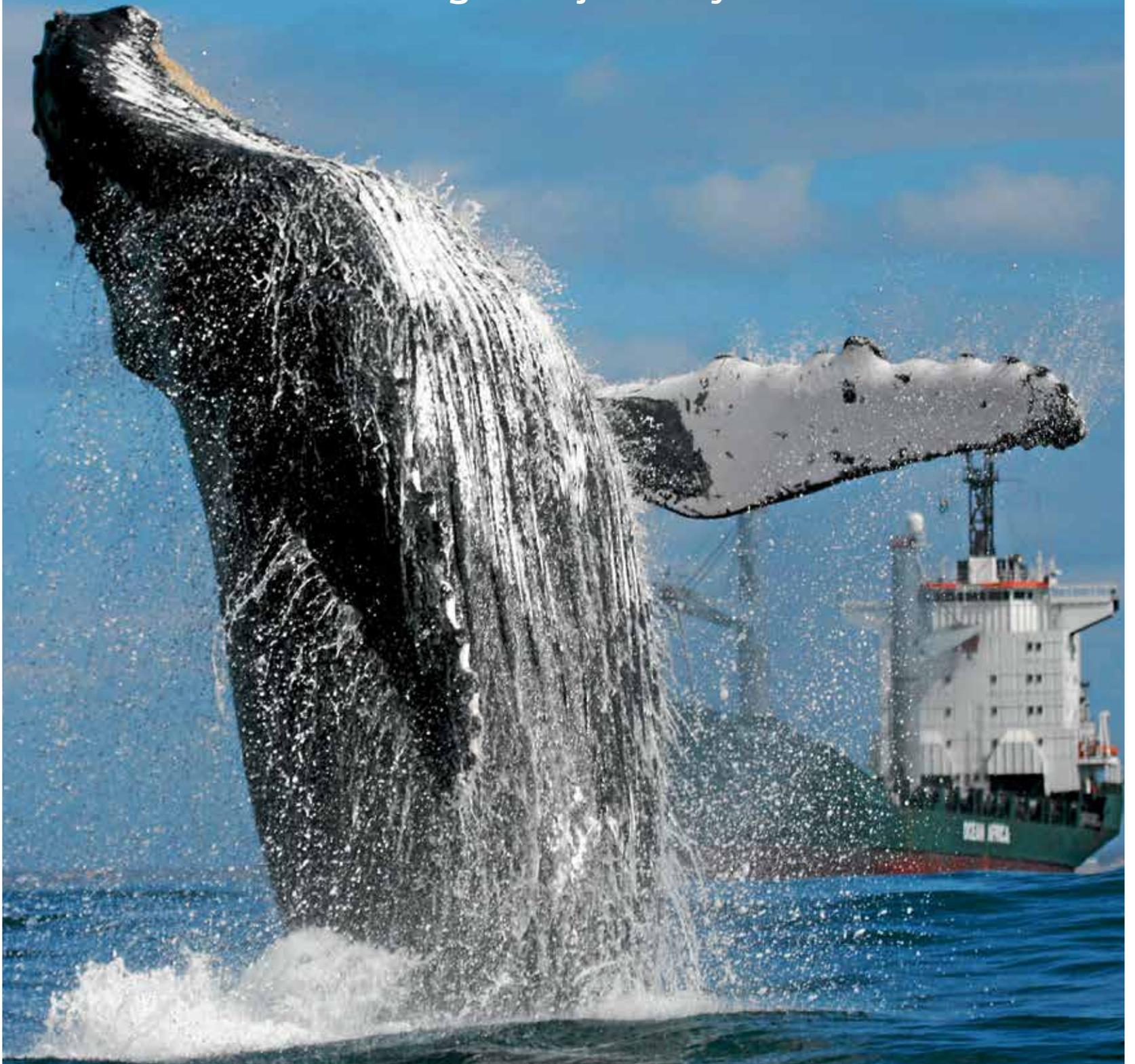


Ocean Sciences

an exciting new journey for South Africa



SA's first dedicated
Ocean Sciences Campus **8**

Fast-tracking Africa's
blue economy **18**

A big need
for new skills **29**

FASCINATING FACTS ABOUT THE OCEAN



Currently, **58%** of South Africa's gross domestic product (GDP) is based on trade and **98%** of South Africa's trade volume moves by ships



South Africa's rich and productive coastal waters support thousands of jobs and contribute millions of rand to the national economy each year, with coastal goods and services estimated to contribute **35%** to South Africa's gross domestic product (GDP).

With its **800km** of coastline, South Africa's Eastern Cape is set to become South Africa's leading hub of maritime economic activity. The province is home to the two major port cities of Port Elizabeth and East London, both established industrial manufacturing coastal centres.

50-70% of our oxygen comes from the ocean. That's more than is provided by all of the world's rainforests combined.



At present an estimated **30%** of the CO₂ released into the atmosphere from human activity dissolves into the oceans.

20-25 million tonnes of CO₂ are being added to the oceans each day, increasing the acidity of ocean waters and threatening the survival of many marine species.

Humans have climbed Mount Everest and walked on the moon, but **95%** of the Earth's waters are still unexplored.



by **2050** oceans could contain more plastics than fish



Tiny phytoplankton provide **50%** of the oxygen on earth and form the basis of the ocean food chain up to fish and marine mammals, and ultimately human consumption.



CONTENTS

- New oceanography and food security innovation bridge between SA and the UK **6**
- On the making of a new generation university **8**
- From space to earth to water: the composites revolution **10**
- Combating sea fisheries crime **11**
- Four fish or 15,000 fish – the choice is in our hands **12**
- Middle Stone Age people got smart at the coast **14**
- 'Extraordinary' Eastern Cape rock pool systems **16**
- Sea law for Africa **18**
- The complicated task of ocean zoning **20**
- It's about working together to fast-track SA's blue economy **21**
- Bringing shipbuilding and marine engineering to Nelson Mandela Bay **23**
- 40 years of coastal and marine research **25**
- Ocean Sciences growth hub for Port Elizabeth **26**
- Aquaponics yields fresh fish, produce - and partnerships **27**
- Future ocean sciences students need to learn to swim **28**
- Harnessing the potential of our oceans for a sustainable future **29**
- Exciting new career opportunities **30**



Professor Derrick Swartz

This bold new journey

Nelson Mandela University's Vice-Chancellor, Professor Derrick Swartz, has been the driving force behind its bold new Ocean Sciences Strategy since around 2014. This strategy arises from his passionate belief that the university enjoys a number of competitive advantages enabling it to become the leading Ocean Sciences university on the African continent – its geographical location on the eastern seaboard, in a major port city (Port Elizabeth) with two major ports, over 40 years of ocean sciences expertise, its establishment of a dedicated new Ocean Sciences Campus, and the roll-out of an exciting generation of marine and maritime science academic programmes. He spoke to us about his vision and strategy in this regard.

ARTHUR C. Clarke once aptly reflected on "how inappropriate to call this planet Earth when it is quite clearly Ocean". The ocean mass covers about 71% of our planet's surface and comprises 97% of its water mass. It plays a crucial role in earth's climate system – regulating its average temperatures and storing over two-thirds of earth's active carbon dioxide.

Our oceans are indispensable to human life. Yet it is an irony that many aspects of the world's oceans are understood in superficial and fragmented ways – despite great scientific progress over the past century. It is often remarked that we know more about the surface of the moon than the oceans on earth.

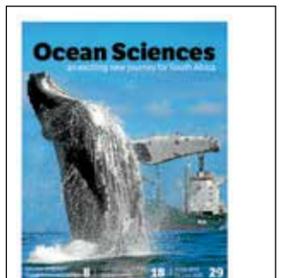
Barely 5% of the ocean mass has been explored, and the vast majority

of the seabed still has to be mapped. Only a small fraction of all its estimated life forms – from large creatures to millions of microbes – have so far been discovered and classified.

We are also only beginning to understand its complex, dynamic marine ecosystems, and a great deal more work is required to develop fine-scaled, time-sensitive modelling of how human activities impact on specific ocean regions – crucial for marine spatial planning and ocean protection strategies. And the Southern (Antarctica) and Indian Oceans are least explored compared to what we know about the Atlantic and Pacific oceans.

Perhaps apart from the interior of the earth, our oceans remain to be the last great unknown to earth science.

What we do know is that water



This humpback whale (*Megaptera novaeangliae*) photographed during a research study in Algoa Bay in 2009 reflects the challenges of maintaining a healthy ocean when facing the growing pressures of global change. Photograph: Stephanie Plön

is key to DNA-based life forms. And there is mounting evidence suggesting that the earliest life forms may have started in Earth's primordial oceans (for example hydrothermal vents) some 3.8 billion years ago.

We certainly know from written records and oral traditions (songs, folklore) that human life, from the dawn of time, has had a long connection to the sea – from Stone Age hunter-gathers who survived in caves along the Southern African coastline some 200,000 years ago; the first Africans who left our continent some 70,000 years ago, and radiated across different parts of the world, in the process taking the world's first African explorers to new lands; to the sea-faring Phoenicians who first sailed the Mediterranean, and Polynesians who discovered Australasia; the ancient Chinese and Nordic mariners of 11th centuries; 16th and 17th century explorers and conquistadors who colonised different parts of the world; to the modern age, when a new era of seafaring emerged on the back of the industrial revolution and rise of global capitalism.

Today, the sea is a vital part of human economic and cultural life. In the modern era, particularly after the Second World War (1939–45), sea-based trade and economic activity had seen exponential growth, employing millions, generating huge revenues, and bringing consumer goods within reach of nearly all the earth's populations.

The global financial crisis of 2007/08 saw a marked decline in growth of the global ocean economy. However, in recent years there has been a resurgence of interest by states and investors in the ocean economy as a source of global economic stimulus.

Traditional sea-based industries were largely based on wild fishing, shipbuilding and shipping, port development, near-shore oil and gas, and logistics. In recent years, a new generation of ocean economy sectors has begun to emerge on the back of the old – marine robotics, ship automation, deep-sea oil, gas, tidal, wind and wave and energy, marine biotechnology and seabed mining.

The OECD (Organization for Economic Cooperation and Development) estimates growth in value of the ocean economy from USD 1 trillion in 2012 to over USD 3 trillion by 2030, with highest growth forecast in maritime cruising and tourism (26%), followed by oil and gas (21%), and port expansion (16%).



The Nelson Mandela Bay harbour, along with the nearby Coega deep-water harbour, will play a key role in growing the country's blue economy. Photograph: Rob Duker

At the same time, there has also been a dramatic population expansion of the world's coastal cities and regions (over 1.4 billion people in 2012) and with this, new pressures on, and risks to, the coastal and marine environments – growing levels of industrial and civil pollution of chemicals, waste, and plastics affecting the underlying health of our oceans.

What makes this period distinctive is that the new drive for growth in the global ocean economy is taking place at a time of major changes in the earth's climate system (itself the result, at least in part, of previous industrial activity) – higher levels of CO₂ released into the atmosphere warming up our oceans, melting of the polar regions, sea level rises, and increasing levels

of ocean acidification.

Together, these pressures have been affecting different parts of the world's marine ecosystems – reduction of wild fish stocks; bleaching of coral reefs in large parts of the world; changes in developmental and reproduction rates of many types of marine species; and accelerated environmental changes outpacing the adaptive resilience of marine ecosystems.

Today, the biggest challenge of our generation, arguably, is that of sustainability. To balance human development – as expressed in the Sustainable Development Goals (SDGs) – with planetary sustainability will require major transformations: in the ethics and patterns of human consumption; our

understanding of natural systems; our respect for biodiversity and ocean health; and importance of evidence-based policy-making and decision-making systems.

If South Africa's policy goal – as expressed in Operation Phakisa Ocean Economy – is to grow GDP value to R177bn and create a million jobs by 2033 by stimulating economic activity in our oceans and coasts, such goals, I would argue, must be moderated by a deeper understanding of how best to manage the difficult challenges of sustainability; and this in turn requires better investment in basic and applied science and technology to build better understanding of our marine ecosystems and investment in growing new careers and skills, especially in areas previously

neglected or narrowly developed – for example marine spatial planning, deep-sea oceanography, climate modeling, bioacoustics and long-range studies of the Indian and Southern Ocean systems.

Moreover, there is a real need to grow the contribution of social sciences and humanities in promoting sustainable ocean development.

Firstly, if human adaptation is a prerequisite to ecological sustainability, then we require more effective tools to promote ecological citizenship. Secondly, if Operation Phakisa Ocean Economy is to avoid reproducing the same patterns of inequality we see, for example, in the mining and financial sectors, then we must find more effective models of economic ownership,

participation and inclusion – particularly focused on marginalised and poor communities.

Nelson Mandela University is committed to a research and training agenda that brings questions of social justice and equity into focus. We also hope to contribute to recording "hidden maritime histories" – the stories and heritage of coastal and island peoples in Africa and western Indian Ocean islands.

Our goal is to develop Nelson Mandela University into a globally recognised, cutting-edge, innovative and pioneering "laboratory" for generating original and applied knowledge to deepen our understanding of ocean dynamics – its geophysics, chemistry, biology, climate system, economic, social and

cultural value, its history and future in a world under twin pressures of human activity and climate change.

Towards this end, the university has adopted a bold new Ocean Sciences strategy to drive a new research, training and innovation agenda to help finding better tools for managing the twin challenges of human development and ecological sustainability.

In this context, we have begun to expand academic offerings in fields such as oceanography, marine engineering, maritime economics and logistics, marine tourism, port development and management, marine spatial planning and the law of the sea, including fisheries law enforcement.

In the next few years, we hope to recruit a new generation of smart students, academic staff and researchers to get top-class training in critical fields.

Secondly, the university has recently begun with the establishment of a new and dedicated Ocean Sciences Campus in Nelson Mandela Bay, to focus and grow our capabilities in a selected number of areas. We have already invested R60m in the new campus, and will be investing a further R75m over the next three years in new infrastructure, labs, equipment and staff to facilitate this new growth area.

Nelson Mandela University currently holds four NRF-funded SARCHI (South African Research Chairs Initiative) Chairs in Marine Spatial Planning; Ocean Science and Marine Food Security, Shallow Water Ecosystems; and Law of the Sea and Development in Africa.

In 2016, we launched three new research and training entities – Centre for Marine and Coastal Research (CMR), the FishFORCE Academy, focused on fisheries protection (with a R50m Norwegian government grant), and Centre for Coastal Paleoscience doing discovery research on early human origins along the southern coastlines of South Africa.

In 2015, the university also established the South African International Maritime Institute (SAIMI), focusing on maritime policy and training, with a R265m grant from the National Skills Fund.

Since last year, we have also begun to position all our seven faculties (Science; Engineering, the Built Environment and IT, Arts, Education, Law, Health Sciences and Business and Economic Sciences) to align current programmes and create new programmes at undergraduate and post-graduate levels around

key niche ocean sciences areas. Nelson Mandela University has over 40 years of scientific expertise in coastal and marine sciences that we hope to build on into new directions into the future.

The institution is the only South African university bearing a "comprehensive" knowledge and skills profile with a prime location right at the coast. This profile brings together basic, formative and applied, professional knowledge competencies in Ocean Sciences in novel ways.

This is a huge strategic advantage in that we can bring to bear to do both discovery research (exploring our oceans) and simultaneously also help to solve real world problems arising from the imperatives of human development needs and ecological sustainability.

I am excited about the prospects of Nelson Mandela University becoming the leading Ocean Sciences University on the African continent. We are hugely encouraged by our growing portfolio of international partnerships in ocean sciences, including Universities of Southampton and Plymouth (UK), Agder and NTNU (Norway), Alto (Finland) and Nairobi (Kenya) and Zanzibar.

If the twin goals of modern science are to explain the world and solve real life problems, we believe that the university's Ocean Sciences future opens up a new horizon of exciting opportunities for students, scholars and other stakeholders of "blue commons" to join hands with us in this bold new journey, which is certainly one of the most exciting developments in the history of the university.

Ocean Sciences Campus Launch

The country's first dedicated Ocean Sciences Campus will be launched at Nelson Mandela University in Port Elizabeth on 22 September.

Representatives from government, industry, civic society, conservation and international partners, including overseas universities, will attend the event at the revamped former CSIR campus, opposite Nelson Mandela University's North and South campuses.

See the new-look campus on pages 8 and 9

New Oceanography and Food Security Innovation Bridge between SA and the UK

By 2050 there will be nine billion people on Earth, with populations growing fastest in the low-lying coastal regions. Many of these communities rely on the oceans for food security, but the oceans are warming and food security risks are rapidly rising.

WHAT sustains marine food security? What are the underpinning ecosystems and how do they function in this era of climate change and changing global oceans?

These questions are the focus of marine specialist scientist Prof Mike Roberts, the incumbent of the Research Chair in Ocean Science and Marine Food Security at Nelson Mandela University. The Chair is jointly hosted by Nelson Mandela University, the University of Southampton (UoS) and the Southampton-based National Oceanography Centre (NOC) – the United Kingdom's leading marine science research and technology institutions.

To find answers, he is investigating marine upwelling systems in the Western Indian Ocean, an under-researched region, which extends all the way up the eastern coast of Africa, including Somalia, Kenya, Tanzania, Mozambique, South Africa, and

the island states of Comoros, Madagascar, Seychelles, Mauritius and Réunion.

Upwelling, Prof Roberts explains, is the upward movement of deep, cold, nutrient-rich water to the ocean surface, encouraging the growth of phytoplankton (microplants which form the base of the marine food web), which ultimately provide energy all the way up the food web to reach the top marine predators. Upwelling and the ocean physics causing it, directly underpin marine food security.

As the planet's climate is changing, so is the ocean's upwelling system, strongly affecting all levels of the food chain. In the Western Indian Ocean (WIO) region, over 60 million people are directly dependent on the ocean for their food and livelihoods. In addition to climate change, the region is also experiencing the rapid deterioration of the marine environment caused by overfishing, destructive forms



Climate change – and the resulting warming oceans – are impacting our food resources from the sea.

of fishing such as with the use of dynamite, and high levels of pollution.

“To find answers as to how to address this requires an intensive transdisciplinary research approach from physics to fish to forecasts. This encompasses research in physical oceanography, biogeochemistry, plankton, trophic ecology, fisheries and food resources, quantified by end-to-end ecosystem and socio-economic modelling,” says Prof Roberts, who spent 26 years working as a specialist marine scientist for the South African government's Sea Fisheries Research Institute (SFRI), Marine and Coastal Management (MCM) and Department of Environmental Affairs' Oceans and Coasts Division.

The Chair's research programme, called the Western Indian Ocean Upwelling Research Initiative (WIOURI) embraces transdisciplinary research and uses modeling to determine how, and by how much, climate change and a changing ocean is going to impact food resources in the WIO.

“In addition to our research, concerted emphasis is placed on linking and transferring our research outputs into ocean governance and food security structures including national government, international governments and the Food and Agricultural Organisation (FAO) of the United Nations. The FAO is thoroughly involved in WIOURI as its EAF-Nansen Project is a core partner,” says Prof Roberts.

The EAF-Nansen Project, “Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries”, is all about promoting the sustainable utilisation of marine living resources and improved protection of the marine environment.

The WIO's counterpart, the Eastern Indian Ocean Upwelling Research Initiative (EIOURI), supported by Australia, India, Japan and China, is well-developed, but research in WIOURI is only really getting going now, with the first seven postgraduate candidates and postdoctoral fellows participating in the research required by WIOURI. Student numbers will increase annually as the research programme

builds momentum.

“The link with the University of Southampton (UoS) and the National Oceanography Centre (NOC) creates an invaluable innovation bridge between Southampton and Nelson Mandela University in South Africa, which is ideally positioned to conduct WIOURI research.

“The innovation bridge will have a continuous flow of people and research between the northern hemisphere and Africa, with regional projects extending from South Africa all the way up Africa's eastern coastline.”

A large part of the Chair's work will involve the collection of data using ships, automated subsea gliders, moorings, satellites and ocean models.

“The aim is to exponentially grow research capacity and, in addition to the research exchange, the UoS and NOC are generously loaning us costly research technology.”

A number of postgraduate students from Nelson Mandela University have already spent time at the UoS and NOC to acquire specialist technical skills not yet available in South Africa, and Nelson Mandela University's first research cruise, to collect data off Madagascar, took place in November 2016.

“By offering our students the additional exposure to researchers

and facilities at the UoS and NOC, we are creating a WIOURI Centre of Excellence in Ocean Sciences and a PhD production pipeline at Nelson Mandela University,” says Prof Roberts.

“Few African universities outside of South Africa have anywhere near sufficient numbers of ocean scientists with PhDs and you cannot build the research capacity required to innovate Africa's solutions to food security and other ocean challenges and opportunities without these.”

The comparative example he provides is the new Indian Ocean Marine Research Institute (IOMRI) in Perth, Australia, which has 132 staff members, 82 with PhDs and a new research ship. By comparison one of Africa's chief research institutes, the Institute for Marine Science (IMS) in Zanzibar, established in 1978, uses a ski boat as a research vessel and has 20 staff members and 15 PhDs. “The lack of good research infrastructure hugely impacts our capabilities to do good research that matters,” he says.

“Time is not on our side. Food security and climate change problems are worsening and the WIO is the fastest warming of the world's oceans. Already early measurements show planktonic food in the WIO is declining and coastal and pelagic (offshore) zones are becoming a lot less productive. We have a humanitarian disaster busy unfolding and poor coastal communities have little capacity to adapt for change,” says Prof Roberts, who set up a regional hub in Kenya and Tanzania in February 2016 together with the Kenya Marine and Fisheries Research Institute (KMFRI) and the Institute of Marine Sciences in Zanzibar, which is part of the University of Dar es Salaam.

Through the Chair, he has further secured R160 million from the United Kingdom government as a start-up for two large case studies in South Africa and East Africa. The South African case study will investigate the squid fishery collapse in 2013/2014 off the south coast. The East African case study will build knowledge about the Western Indian Ocean, where almost nothing is known about these tropical, regional marine ecosystems.

“We need to understand, measure, model and predict our marine ecosystems and the impact on their human dependents. We need scientists to come up with a research plan to deal with the situation. Hopefully from this we can come up with mitigation measures and a plan for adaptation.”



Prof Mike Roberts holds the Research Chair in Ocean Science and Marine Food Security, which is jointly hosted by South Africa and the United Kingdom.

“Time is not on our side. Food security and climate change problems are worsening and the Western Indian Ocean is the fastest-warming of the world's oceans ... We have a humanitarian disaster busy unfolding and poor coastal communities have little capacity to adapt for change”

On the making of a new generation university

THERE is excitement in the air at Nelson Mandela University, and in the city and province where the bulk of the institution's campuses are located. And so it should be for the rest of the country and the continent as well, for the launch of a dedicated Ocean Sciences Campus - South Africa's first and only one - marks a hugely significant milestone.

The Ocean Sciences Campus has been a long time coming. It, like the new, recently-launched Nelson Mandela University name, constitutes a trajectory which has its genesis in the institution's 2020 vision and strategy, birthed in 2010. The vision and strategy whose formulation and execution, led from day one by Vice-Chancellor Prof Derrick Swartz, has been and is about repositioning the university in South Africa, continentally and globally.

It is a repositioning that begins and ends with the reimagining of the academic project. This entails, among others, and as articulated by our Vice-Chancellor, the following:

- Reinigorating curriculum renewal with a defined set of epistemological and curriculum statements, involving issues of social justice, democracy, equality and sustainability, ecological justice, globalisation, technological change and the changing nature of work;
- Establishing faculty transformation committees, involving students and staff facilitating co-creation of curricula, teaching and learning, research and engagement and innovations praxis; and
- Rinning staff orientation workshops of all academics to embrace the new knowledge and curriculum paradigm.

It is a cause endorsed recently by Deputy President Cyril Ramaphosa when we celebrated the renaming of the university. On the day he said: "The decision to become Nelson Mandela University is not simply an exercise in corporate re-branding. It is a statement of intent. It is a statement of values. It is a validation of the struggles of our people against

colonial occupation and apartheid oppression. It is an affirmation of their history and identity, of their dignity and rights."

The act of renaming of the university "makes a statement about justice, rehabilitation and reconciliation. It starts to reshape our South African identity. It helps us to move forward, together, as a people. That is because Nelson Mandela embodied the best in us."

And so the launch of our Ocean Sciences Campus on 22 September 2017 needs to be located squarely in

this context, as an intellectual and academic proposition that enables the exploration of the frontier of new knowledge, in innovative and trans-disciplinary ways, in ways that help us to take all our people with us and in ways that move us forward, as a people, nation and continent.

The campus is intended, in the words of Prof Swartz, to be a creative hub for pioneering and ground-breaking transdisciplinary, postgraduate ocean sciences research, teaching, innovation and engagement that should put

Nelson Mandela University in a clear position to become the leading ocean sciences university on the African continent.

In establishing and running the Ocean Sciences Campus, the university will work in close collaboration with the public and private sector, with local, continental and overseas universities and institutions, with a core focus on South African oceans, and an interest in extending to East Africa, Indian Ocean Rim countries, the Southern Indian Ocean and

Antarctica.

The research, teaching and training, innovation and engagement will initially focus on four wide-ranging themes:

- Marine food security and sustainable livelihoods for coastal communities;
- Ocean governance and global change;
- Oceanography and marine biodiversity conservation; and
- Marine technologies and infrastructure.

As we launch the new Ocean Sciences Campus, our Faculty of Health Sciences is hard at work preparing for the eventual launch of South Africa's 10th medical school. It will be the second in the Eastern Cape - a province with one of the largest rural footprints in dire need of training and development of wide-ranging medical facilities and services.

The orientation and work towards the medical school is equally and intentionally focused not only on training and graduating students and practitioners, and integrating them into the health profession's workforce, but is also focused on promoting healthier lifestyles, community health and wellbeing, food security and poverty alleviation, and economic development.

The above represents a deliberate institutional strategy aimed at creating, building and enhancing a differentiating and distinctive identity and brand, that coheres and remains true to our vision, mission and values, that resonates with what former President Nelson Mandela stood and lived for, which is thankfully embodied in our new name.

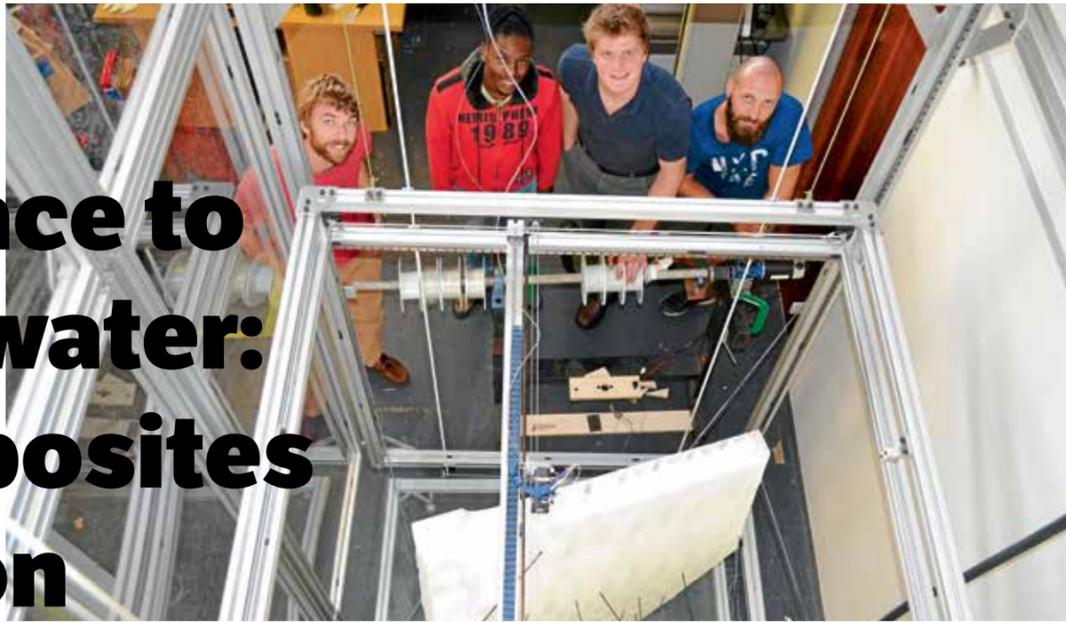
Lebogang Hashatse

Senior Director: Communication and Stakeholder Liaison
Nelson Mandela University



Standing five metres tall, the 3D printer is for the manufacturing and rapid prototyping of moulds required for the composites industry.

From space to earth to water: the composites revolution



Composites engineering is starting to gain momentum worldwide, with new materials from the international aerospace programmes now being used in a wide range of industries – including marine engineering – for lighter, stronger, more energy-efficient construction.

TO assist in the development of new composites in South Africa, funding from the Department of Science and Technology (DST) for a Collaborative Fibre Composites Project (CFCP) was received last year by Nelson Mandela University's internationally recognised innovation hub, called eNtsa.

"The CFCP is a skills-development programme because there is a huge growth and employment opportunity in the development of new composites for a wide range of construction needs, including marine, automotive, aviation, and renewable energy; many wind turbine components are made from composites; and we need to be able to do all this in South Africa," says eNtsa Engineering Director Andrew Young.

The DST wants to see strong skills development and research outputs from its investments and eNtsa delivers this.

"As part of the CFCP's skills development programme, we built a four-metre lightweight recreational boat ... We laser-scanned it, used a CAD (computer-assisted design) system to create a virtual prototype, then we revised the shape of the hull, added our own deck features and used vacuum infusion as the build technology to create a boat that is stronger and less than half the weight (±70 kg) of the similar

existing model (±200 kg).

"One of the lightweight boat prototypes will be used to train Marine Engineering students, who can gain sea experience on it and get a skipper's licence. The other will go to the Nelson Mandela Bay Composites Cluster at Propella (the bay's university-linked business incubator) as a demonstrator of lightweighting."

Young says the commercialisation of developed technologies, engineering services and high technology human resource capability is a key strategic objective for eNtsa. Focus is placed on activities that will advance the local engineering community, create new nodes for economic

"... there is a huge growth and employment opportunity in the development of new composites for a wide range of construction needs, including marine, automotive, aviation, and renewable energy ... and we need to be able to do all this in South Africa ..."

and employment opportunities and secure eNtsa and the university's future growth and sustainability through direct and indirect partnerships with the commercial entities it partners with and incubates.

"In the composites development and construction process for wind turbines or light aircraft structures, for example, we need skilled people to make use of the advanced materials that have come out of the aerospace programmes, and we require skills for their maintenance and repair. Both skills are scarce in South Africa. Wind turbine blades, for example, need to withstand harsh conditions, including high-speed winds and hail, and we need people to repair them on site, 100 m in the air."

Through the CFCP, Master's student Timothy Momsen developed the largest 3D printer in South Africa for his project. Standing five metres tall, the 3D printer is for the manufacturing and rapid prototyping of moulds required for the composites industry, such as moulds for wind turbine blades. It can also produce other three-dimensional, structurally sound solid objects from digital files.

"The 3D printer is ideal for research and invention. Not only can researchers print the components, we can now accelerate prototype

research to an unprecedented degree by adapting or adjusting designs on the computer in an instant and then simply pressing 'print' again," says Prof Russell Phillips, senior Mechanical Engineering lecturer and the head of the Renewable Energy Research Group (REG) within Faculty of Engineering, the Built Environment and Information Technology.

"This is invaluable for the advancement of the renewable energy industry, which is a major growth area for South Africa that is booming in the Eastern Cape.

"At Nelson Mandela University our goal is to be a global leader in applied renewable energy and we are attracting increasing numbers of engineering postgraduates who are interested in this field."

"To advance our students' skills we are setting up a composites skills development and research lab that will be used by undergraduates and graduates alike," says Young. "The DST is the funder and we are collaborating the CSIR, with whom we have also worked closely on the CFCP."

One of the CSIR's research areas is on the replacement of costly synthetic fibres with natural fibres.

"The opportunities for using these fibres are huge; over and above aircraft, motor vehicles and yachts, they can be used in the insulation of buildings and in the door panels of motor cars, which Mercedes is already doing," says Young. "The revolution is upon us and we cannot wait to see what we develop and what gets taken to market over the next couple of years."

Combating sea fisheries crime

"FISHERIES crime and the illegal harvesting, processing and trading of fish and seafood globally is so huge that it is in effect a parallel economic system that is undermining sustainable economic growth."

So says Prof Hennie van As, Director of the Centre for Law in Action (CLA) at Nelson Mandela University, who has joined the global fight against fisheries crime, through FishFORCE, a Fisheries Law Enforcement Academy which was established at the university in 2016, as a partnership between the CLA, the Norwegian Department of Trade, Industry and Fisheries and South Africa's Department of Agriculture, Forestry and Fisheries (DAFF).

"FishFORCE's main purpose is to combat sea fisheries crime and related criminal activities," says Prof van As, who is also a member of an international partnership on fisheries crime between South Africa and Norway, called PescaDOLUS.

"We have started training fisheries control officers (FCOs), police officers and prosecutors in South Africa and Kenya, and we will be doing the same in other countries along the East African coastline.

We are also assisting with

training along the Indian Ocean Rim, including countries like Indonesia."

Norway committed R50m over five years for the establishment of FishFORCE, which also has the buy-in from the world's largest international police organisation, INTERPOL, the African Union and the United Nations Office on Drugs and Crime because the oceans links all nations, and porous harbours or borders are a danger to all.

FishFORCE will work to achieve knowledge- and intelligence-led investigations and increase successful prosecutions of criminals engaged in fisheries crime. It will also enable fisheries law enforcement officers to obtain formal qualifications, including higher certificates, diplomas and postgraduate diplomas, with access to further academic qualifications.

"FishFORCE is critical for South Africa where, as is the case in most developing countries, the training of FCOs, police officers and prosecutors involved in fisheries law enforcement is conducted on an

ad hoc basis. There are no courses specifically designed to train them to fulfill their enforcement duties," says Prof Van As.

"Together with the National Prosecuting Authority, we will be getting to the bottom of why prosecutions for fisheries-related crimes often fail.

"The regulating, policing and law enforcement of fisheries vessels in the past has been too compartmentalised and full of loopholes because of the large number of different players involved.

"Illegal fisheries vessels take advantage of this. They commit document fraud to under-report catches, they fish illegally and they change their flags (because countries only have jurisdiction on the high seas over vessels that fly their flags) or they transfer illegally caught fish from one boat to another.

"We are now closely collaborating with the South African Police Service, Defence Force, Navy, National Prosecuting Authority and Home Affairs to develop a combined offensive."

South Africa recently amended its legislation to give municipal law enforcement officers the powers of FCOs. FishFORCE is giving

the required training to municipal law enforcement officers.

Last year, FishFORCE ran five workshops in South Africa to train additional fisheries control officers and Honorary marine conservation officers as part of a public works programme, with former Umkhonto soldiers as part of the group.

Also in 2016, FishFORCE co-hosted the high-level International Sea Fisheries Crime Conference in Yogyakarta, Indonesia, which is establishing a counterpart fisheries law enforcement academy. And it co-hosted a high-level conference in Mombasa, Kenya, together with the University of Nairobi and the Kenyan Department of Fisheries, where government authorities from Kenya, Somalia, Mozambique, Tanzania, Indonesia, Mauritius and Seychelles came together to discuss the combating of fisheries crime, including significant poaching by Chinese fishing boats.

"South Africa faces the same problem, with several Chinese fishing boats apprehended in our waters, but what people have to realise is that highly organised, well-financed transnational criminal activities are taking place within our waters and within international waters all the time. These activities include a lot of other issues, including human and drug trafficking."

Research by the United Nation's Food and Agricultural Organisation (FAO) estimates that Southern and East Africa lose in the region of R12.2 billion to illegal and unreported fishing every year. The FAO further estimates that 85% of fish stocks worldwide are now fully exploited, and illegal fishing is one of the main contributors.

"We need to face up to the fact that traditional legal approaches to combatting illegal fishing and the associated illegal activities have met with limited success.

"An alternative approach that is gaining momentum is to approach illegal fishing as a transnational organised crime, and to investigate the policing, legal and policy implications of using transnational criminal law and procedure to strengthen fisheries law enforcement."

Website: <http://cla.nmmu.ac.za> and <http://fishforce.nmmu.ac.za/>



FishFORCE's main purpose is to combat sea fisheries crime and related criminal activities.

Four fish or 15,000 fish – the choice is in our hands

The research conducted by marine biologist Prof Nadine Strydom – Africa’s leading expert on early stage fish (larvae and juveniles) – contributes to fish ecology, conservation, fisheries and aquaculture.



A collection of zooplankton in Algoa Bay from a larval fish research survey.

Photograph: Prof Nadine Strydom



Zooplankton (Copepods).

Photograph: Roland Birke



Sardines offloaded at the harbour from a local purse seine fishing vessel.

Photograph: Prof Nadine Strydom



‘Constantly asking questions about how nature works’

Prof Nadine Strydom (left) was Nelson Mandela University’s Researcher of the Year: she explains what it took to take top honours for research

“I’m constantly asking questions about how the natural environment works and how fish function in their natural habitat and in response to human pressure – this is extremely important from a biodiversity, harvesting and food security perspective.”

Prof Strydom is also committed to growing the number of postgraduate students in marine biology and encourages publishing all her science with students.

Recent work with graduate Dr Paula Patrick in the international marine science journal, *Marine Ecology Progress Series*, has made some important advances in understanding fish spawning, including “that spawning occurs closer to shore than what was previously thought”.

Prof Strydom confirms that many nearshore habitats are underexplored and are extremely important spawning and nursery areas for fish that we rely on for food. The value of the Eastern Cape as a fish nursery hotspot in South Africa is underestimated and there are a plethora of habitats along the coast that are poorly studied often because they are dangerous to work in.

The province is home to the large Agulhas Bank in the ocean and the most open estuaries in the country, as well as many small bays and surf zones that are key fish areas. All this needs to be taken into consideration in marine spatial planning initiatives that serve fish conservation in a changing world.

OVERFISHING of South Africa’s linefish has put them in survival mode, with smaller, younger fish becoming sexually mature – but producing far fewer and much smaller eggs, with only a handful of babies surviving.

And so numbers continue to drop, says Nelson Mandela University marine biologist Prof Nadine Strydom, who wastes no time getting to the heart of the country’s fishing crisis.

“Many coastal linefish species can live for over 30 years but because of over-fishing, their populations have either collapsed or the numbers of older, mature adults have dangerously plummeted. Their survival response is that the smaller, younger fish are becoming sexually mature at a younger age, which is not good for the species because they do not produce nearly the same amount or size of eggs, which affects the survival of offspring.

“Less than 0.1% of all spawned, fertilised linefish eggs make it through to adulthood. If we look at the dusky kob as an example, at 10 years, it can produce 4,000 eggs per spawning season once a

year and only 0.1% or four of their offspring will survive to adulthood under natural conditions. A 30-year-old dusky kob can produce 15 million eggs per spawning season once a year and 0.1% will survive, which is 15,000 fish.”

Stocks of South Africa’s iconic angling fish species – such as red and white steenbras, black musselcracker, dageraad, kabeljou (kob) and seventy-four – are now so overexploited that they fall within the red list of threatened species, as tracked by the International Union for the Conservation of Nature (IUCN).

When it comes to the musselcracker, targeting the largest, mature fish completely derails the species’ sex ratios, as the entire population is female for the first 18 years of their lives and become males thereafter.

These examples illustrate the importance of Prof Strydom’s research, which uniquely explores fish reproduction across wetlands, rivers, estuaries and the ocean. Her speciality, which is a scarce skill worldwide, is focused on the early developmental stages of fish that are so tiny they can only be viewed

under a microscope. She tracks the larvae of fish – monitoring their movement from the sea (where fish spawn) to the surf zone (where fish larvae are part of the plankton) to estuaries (where they grow into juvenile fish) and in some cases, even up-river where certain marine fish make use of unique nursery areas.

Her research on the larval stages of temperate southern African fish species spans a geographic study area extending from the middle of the Transkei coast all the way to Angola.

This research is so important because an understanding of fish larvae and juvenile survival can help with predictions about the size of future fish populations. “It’s a well-known scientific phenomenon that the success of any fish population is underpinned by the success of the larval phase, which is directly related to environmental conditions, habitat threats such as pollution and overharvesting of breeding adults.

“Because we understand how devastating it is to remove the oldest fish, which are the best breeders, producing larger eggs and stronger offspring, part of our work is to encourage anglers to release the prime stock they catch.”

There are approximately 2.5 million active recreational anglers in South Africa from every socioeconomic, age and gender group. They play a major role in the conservation of our fish stocks. The definition of recreational angling ranges from catching fish from the shore to catching from rowing boats or ski boats or with spear guns.

While the Department of Agriculture, Forestry and Fisheries monitors the catches of the 22 commercial fisheries in South Africa, there is inadequate effort in the monitoring of the catches in recreational angling, other than the number of permits sold and various surveys with fishers along our long coastline.

“Policing of recreational fishing is almost non-existent. People are taking undersized fish and taking more than they are legally allowed and our natural resources are struggling to recover from the pressure,” says Prof Strydom.

An important part of her work is to educate the fishing and coastal communities about fish, their life cycles, pollution and how

we are directly threatening the sustainability of species which feed and support millions of people and are vital to the functioning of our ecosystems. She is on the management committee of the Swartkops Conservancy, an environmental education NGO in Nelson Mandela Bay, which is on a major engagement drive to meet with citizens living in the vicinity of estuaries to talk about sewerage, industrial and agricultural pollution, plastic and microplastics, which are posing a major risk to our marine life. She gives presentations and provides educational material to coastal communities and schools about overharvesting of resources and how pollution affects river systems and estuaries and ultimately the food we eat.

Prof Strydom is pioneering the use of specialised biochemical analysis used in northern hemisphere fisheries and applying this to ecology in estuaries in South Africa in collaboration with the GEOMAR Research Institute in Germany. “We are using a fisheries tool in an ecological context, to understand the body condition of fish in nursery areas that are under

threat from waters polluted by agricultural runoff and sewage,” she explains.

Her work has already shown that young fish that are being consumed in the recreational fishery on the Swartkops Estuary are contaminated with heavy metals such as cadmium. Fish that are contaminated in their nursery areas subsequently swim to neighbouring estuaries as adults where the contamination is extended.

Another area of concern that falls within Prof Strydom’s research domain is the shortage of freshwater flow from the river system into estuaries because of large dams like those on the Kariega, Bushmans and Krom rivers. The inflow of fresh water is essential to estuary health. “Many people don’t realise the life link between rivers and estuaries is necessary for marine ecosystem survival. Many of our key linefish species use estuaries as nurseries, including the dusky kob, white steenbras, garrick, spotted grunter and many others,” Prof Strydom explains.

“Many fish species also cross

multiple habitats in their lives. The moonies, for example, spawn at sea, and use the estuaries and mangroves as their nursery areas. As juveniles they can even move up rivers and feed on insect larvae and when they reach maturity they go back out to sea.”

In Prof Strydom’s field it often takes years to gather the different parts of the life cycle puzzle for different species and put them together to start understanding the bigger picture of how fish use their environment from hatching to adults, many of which become part of fisheries. South Africa has exceptional marine biodiversity with approximately 2,700 fish species; many are found only in southern Africa and our knowledge of the full life cycle of many fish species is still unknown.

“There is so much that still needs to be investigated about even our best-known coastal fishes. Key aspects of their biology and ecology are still unknown, such as where they are spawning. We are busy with cutting-edge research but at the same time we are trying to plug the leaking holes created by pollution and over-fishing.”

Middle Stone Age people got smart at the coast

BEING able to use fire to engineer weapons out of stone, and perhaps even read the lunar cycles to know when the tides would be low enough to forage for shellfish, are some of the signs that Middle Stone Age people first developed intelligence along South Africa's southern Cape coast.

An international, multi-disciplinary group of researchers has been collecting archaeological, botanical, geological, climate-related and other data in and around the Pinnacle Point caves near Mossel Bay, where it is believed that a small group of *Homo sapiens* survived an Ice Age between 195,000 and 123,000 years ago, and could very likely be the ancestors of everyone alive today.

What they have found has shifted the start of modern humans' cognitive development from some 40,000 years ago in Europe, a view long held in scientific literature, to 100,000 years earlier, in South Africa.

But what is also groundbreaking about the Pinnacle Point study – and likely to set a precedent for other major archaeological explorations – is that the research group is not just relying on its own limited understanding to tell the story about how things were. Instead, they are using state-of-the-art technology to create a computer-generated palaeoscape (the ancient landscape), based on the archaeological artefacts they find, along with the flora and fauna in the area. They then create a computer model of the behaviour of Middle Stone Age people by “releasing” them as “agents” within this simulated landscape, checking how they may have gone about foraging for the

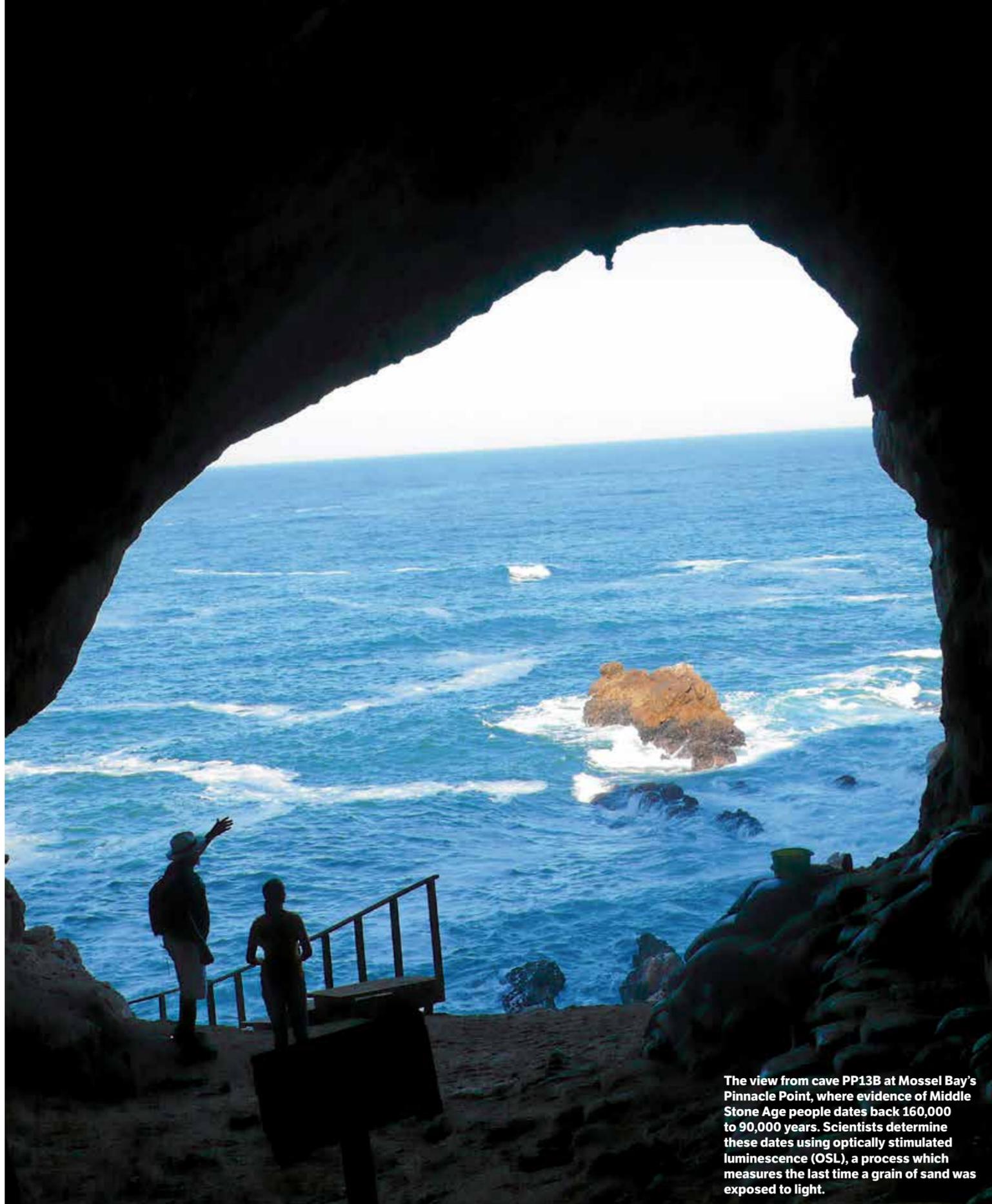
available food resources. Finally, they test the predictions of the model against the archaeological data available.

“We are using the agent-based model to develop hypotheses about how people would have reacted to resources, how they would have obtained them, the success rates of their hunting, how they would have moved around, how many people would have lived and foraged in a 10 km radius, and the optimal group sizes for hunting,” says Nelson Mandela University botany professor Richard Cowling, a co-principal investigator in the SACP4 project (the South African Coast Palaeoclimate, Palaeoenvironment, Palaeoecology, and Palaeoanthropology project), which is led by palaeoanthropologist Prof Curtis Marean, from the Institute of Human Origins at Arizona State University, and funded by the National Science Foundation, Templeton Foundation, and Hyde Family Foundations in the United States.

“This is a very different approach – and it is a world leader in that sense,” says Prof Cowling, who also heads up the Centre for Coastal Palaeoscience at Nelson Mandela University.

“What adds the gloss to this study is that we are looking at the dawn of our species. SACP4 is providing another layer of information, which makes the project [one] of global interest.” Already, a number of articles about SACP4 have been published in the world's leading science journals, among them *Science*, *Nature* and *Scientific American*.

Figuring out what resources



The view from cave PP13B at Mossel Bay's Pinnacle Point, where evidence of Middle Stone Age people dates back 160,000 to 90,000 years. Scientists determine these dates using optically stimulated luminescence (OSL), a process which measures the last time a grain of sand was exposed to light.

were available – and how good people were at extracting these resources – is the first step towards determining how, when and why human beings started to advance cognitively.

“With the evidence available today, one cannot refute that modern cognition emerged on the Cape South Coast ... You can observe more about modern human development here than anywhere else.”

Altogether, SACP4 has 35 researchers from 20 universities from every continent, representing a huge range of disciplines, from archaeology to botany, geosciences, climate sciences, zoology, history and anthropology, who are “trying to put their pieces into the puzzle of building the palaeoscape”, says Prof Cowling's co-worker Dr Alastair Potts, a senior lecturer in botany at Nelson Mandela University, who is responsible for modelling vegetation for the recreated palaeoscape.

“We're at a juncture here. This project has brought together a

“With the evidence available today, one cannot refute that modern cognition emerged on the Cape South Coast ... You can observe more about modern human development here than anywhere else.”

whole bunch of different fields that are advanced enough to incorporate it all together to try and crack the nut of human cognitive evolution.”

The “agent-based foraging model” is based on the research of Arizona State University's Prof Kim Hill, an anthropologist, who used the model to map the movements of the Aché Indians in Paraguay, with 95% accuracy. The development of the model is being led by the University of Colorado's Dr Colin Wren.

Archaeological artefacts found through SACP4 have brought the dates of the earliest heat treatment for weapons from 20,000 years ago in Europe to 72,000 years ago at Pinnacle Point – where “bladelets” crafted out of silcrete rock have been found.

Stone tools were the Swiss army knife of the Stone Age world, and the process of heating the stone to create the “bladelets” took several complicated steps – which involved “baking” the stone under sand – and Stone Age people by then would have had to have developed an effective way of communicating to enable them to achieve what was needed.

“Silcrete was their most important raw material. It enabled them to make these very fine bladelets and to have bows and arrows, with ridged arrow heads ... These tools would have been a major technological breakthrough,” says Prof Cowling.

Over the last decade, South African and other international researchers have also brought the dates of the earliest art works from 20,000 to 30,000 years ago in France, to as far back as 120,000 years ago in South Africa, and the time frames for the development of a true coastal lifestyle based on intertidal resources to about 110,000 years ago. Elsewhere, the coastal adaptation emerged only relatively recently, in the past 30,000 years or so.

Africa's southern Cape coast, with its prolific shell fish and edible plants, and its warm Agulhas current ensuring the coastline didn't ice up, would have been one of the few spots on Earth where humans could have survived at that time.

Nelson Mandela University PhD student Jan de Vynck, supervised by Profs Hill and Cowling, has been looking at the high return rate of foraging in the inter-tidal zone. His Master's research examined the availability of bulbs in the area and found they were abundant just about all year round.

Dr Potts said modelling the vegetation for the recreated palaeoscape was challenging “because you are dealing with an extinct ecosystem as the sea level has changed”. Sea has reclaimed a huge portion of land – leaving much of it under water, thus SACP4 has required the assistance of off-shore marine geologist, Hayley Cawthra, to map the offshore geology, which has included extracting rocks from the seabed in deep, shark-infested waters.

● Nelson Mandela University is showcasing this research in a unique palaeoscience exhibition titled “Point of Human Origin”, which runs till the end of the year. The exhibition includes an artist's recreation of part of Pinnacle Point's cave PPI3B.

‘Extraordinary’ Eastern Cape rock pool systems provide clues to early life



Prof Renzo Perissinotto and his students investigate one of South Africa's minor estuaries, which are at risk of drying up.

COULD the Eastern Cape have played a role in the very origins of earthly life?

The recent discovery of one of the world's earliest life forms right here along South Africa's coastline suggests it could.

In a handful of rock pools around the globe, this early form of life – dating back some 3.7 billion years ago, according to fossil records – can still be found.

It is a bacteria-based system responsible for “growing” the calcified walls of coastal rock pools – and it was recently discovered, in abundance, in the Eastern Cape.

Regarded as the oldest type of biologically-mediated calcified formations on Earth, other rare living examples of these systems are found in Shark Bay in Australia and the Exumas in the Bahamas. But scientists have been taken aback by the sheer number found along the coast, south of Port Elizabeth.

These colonies are giving scientists a glimpse into the hydrospheric (water) conditions that prevailed at the very onset of life on earth.

“They were the only living things in those days – they disappeared with the advent of other, more evolved organisms,” said Prof Renzo Perissinotto, who holds a Research Chair in Shallow Water Ecosystems at Nelson Mandela University and is part of a high-profile team – including two other South African

Chairs and five international collaborators from universities in Norway, Italy, Poland, Sweden and the United States – which has been studying this phenomenon over the past few years.

“This is an area of great interest around the world ... there is an eagerness to know more about how they function, in comparison with those seen in the fossil record”.

“These bacteria-based systems provided the first photosynthetic process that led to the transitioning of the early Earth's atmosphere into its current, productive oxygen-rich state.”

He explained that these bacteria-based formations – called living marine stromatolites – occur when freshwater seepage from the land comes together with seawater in the inter-tidal area, and cyanobacteria (blue-green algae), under certain conditions, play a role in depositing calcite crystals.

“Although other rare, isolated examples of similar formations have been reported to occur from Port Elizabeth to Tofu in Mozambique, the recent discovery of numerous and closely-spaced living stromatolites on the coastline south of Port Elizabeth appears to be extraordinary ... We have discovered over 500 actively-growing marine stromatolites from Cape Recife to Storms River.

“They are a unique feature and are very different to those found in

Australia and the Bahamas.”

If you saw one today, you would be forgiven for thinking it was just a stagnant rock pool covered in a green carpet of algae – not realising that the same growth process that occurred billions of years ago was taking place right before your eyes.

“The process requires super-saturation of the water by calcium carbonate (CaCO₃), which only occurs in today's marine environment under special conditions, for example, under states of hyper-salinity, excess evaporation or the mixing of extremely different water types.”

Perissinotto said the research team, which includes Nelson Mandela University Research Chair in Earth Systems Science, Prof David Bell, and Rhodes University Research Chair in Marine Natural Products, Prof Rosemary Dorrington, along with staff and postgraduate students from NMMU's Geoscience, Chemistry, Zoology and Botany departments, conducted a year-long baseline survey relating to the structure, functioning and age of the stromatolites. The five international universities involved in the research are the Norwegian University of Science and Technology, the University of Padova (Italy), the University of Lodz (Poland), the University of Gothenburg (Sweden) and Oregon State University (United States).

Eight articles have been published in prominent international journals so far on this subject. The first article, published in the *South African Journal of Science*, has called for the government to protect these areas with special legislation, as is done in Australia.

“If we can prove that these structures are similar to the most ancient forms of life that have appeared on this planet, we have got a bit of the ‘origins of life’ story right here.”

Perissinotto is also involved in a number of other research projects, the main one focusing on iSimangaliso Wetland Park, which includes Africa's largest estuarine system (Lake St Lucia).

This UNESCO World Heritage site in KwaZulu-Natal, receives 700,000 to 800,000 visitors a year, coming only after the Kruger and the Cape Peninsula National Parks as the most popular eco-tourism site in the country.

Prof Perissinotto has been monitoring the park on a quarterly basis for the past 12 years, notching up expertise that has enabled him to accurately track the many changes that have occurred through times of drought and flood, and in the transition periods between them.

“We have been able to capture the changes for all these events – and have developed an excellent picture of the major changes in the park's physico-chemistry and

ecology, as well as the biodiversity of the system.”

In 2016 alone, Perissinotto and his team of researchers published eight articles on the changes that had occurred since the previous drought.

He is also promoting rehabilitation efforts at the park. In the 1960s, managers saw fit to establish a dredge-spoil island to disconnect the estuary from the Umfolozi river, the most heavily-silted river in South Africa (they kept the mouth of Umfolozi River artificially opened into the sea) – and the island is now being removed to restore the area to how it once was, with phase one of the project successfully completed.

Over 100 species of marine

fish utilise St Lucia for breeding – these have decreased dramatically because St Lucia is currently a closed estuary [it does not flow into the sea]. “Through the Umfolozi connection, there will be more recruitment ... This is one of the most important [fish] recruitment areas on the African continent ... We are also discovering new species of invertebrates there all the time.”

One of the consequences of restoring the connection between the river and the estuary has been “huge sediments coming into iSimangaliso from the Umfolozi.” However, this is a challenge the Park Authority is now allowing nature to manage.

“It is a situation where we have regular scouring of the system

because of floods. However, when the mouth is closed, there is a steady accumulation of silt, and we don't yet know what this could lead to.” Ideally, increased rainfall in the eastern part of the country would lead to more frequent floods, which would take care of the sediment by breaching the mouth.

Perissinotto said silt scouring through floods was the ideal situation, as it led to more food (phytoplankton) for fish larvae, ultimately leading to more fish in the sea. “It is a more natural system that sets in motion the productivity of the coastline.”

However, climate change has brought uncertainty, with droughts becoming more prolonged, and floods, when they occur, being much bigger.

Perissinotto is also conducting research on the biodiversity of surface and groundwater in the Karoo, as part of a natural baseline study by Nelson Mandela University's Africa Earth Observatory Network-Earth Stewardship Science Research Institute (AEON-ESSRI), which is being undertaken in anticipation of shale gas exploration in this area. “We are mapping 30 to 40 systems, ranging from large dams to small streams to temporary depressions ... We need to put their biodiversity on record before shale gas mining begins, so that we are able to monitor any significant changes that

may occur.”

Prof Perissinotto and his postgraduate students have also been conducting research into the invertebrates living in the waters of the Karoo – which forms part of a baseline study on this area, prior to possible fracking efforts – and they have discovered a number of highly-specialised organisms that have adapted to this area's unique semi-desert environment.

A number of new species are currently being described by world specialists.

“There is large interest worldwide regarding this baseline study, as such studies haven't been done anywhere else in the world [in countries like Australia, the United States and China, where fracking operations are already well underway]. These countries have no comparison with how the situation was before.”

Perissinotto's research in this area has led to publications in three international journals.

Perissinotto is also part of a team, led by the South African Institute of Aquatic Biodiversity (SAIAB), which is studying coastal micro-inlets (minor estuaries), which could possibly dry up in the next decade. “Forecasts predict that water demand will exceed supply by 2025 ... We don't know the biodiversity of these inlets or the role they play in relation to the bigger estuaries.”

Staff and students collect samples at rare living rock pool systems in the Eastern Cape.

Photograph: Lynette Clennell





Sea law for Africa

South Africa has one of the largest maritime zones in Africa with a sea area spanning 2.5 million square kilometres, which is twice the size of our dry land territory. The big question is: How do we govern this vast sea area?

WITH all eyes on the oceans as a rich resource, and with the South African government's focus on the ocean economy through Operation Phakisa, there is an urgency to create and enforce strong, comprehensive laws for South Africa and Africa's maritime domains.

This is no easy task, given that the law of the sea is extremely complex, and there is limited marine knowledge and understanding worldwide. In fact, we know more about the surface of the moon than we know about the bottom of the ocean.

The legal regime that applies at sea is very different to the one which applies on land, explains Prof Patrick Vrancken (left), the incumbent of the South African Research Chair on the

Law of the Sea and Development in Africa, who five years ago wrote *South Africa and the Law of the Sea*, which was the first book published on this subject.

"The sea is divided into maritime zones with different rules in different zones ... You have laws governing the internal waters such as our bays; then you have laws governing the territorial sea extending 12 nautical miles (22km).

"Beyond this is the exclusive economic zone (EEZ) and many people think it is part of the territory of the coastal state but it is not. The law treats the resources found in the EEZ, which extends as far as 200 nautical miles (370 km) from the coastal baselines, as if they were part of the territory of the coastal

"A lot of work is being done [to enforce the law of the sea] with the use of technology such as drones, but many African states do not have the means to protect their waters..."

state, but for all other purposes the zone is subjected to the same laws as the high seas."

Every resource found in the EEZ, from fish to oil, gas and other minerals, belongs to the coastal state, but it cannot prevent any other nation from navigating through this area. In certain cases, however, if the continental shelf extends further than the 200 nautical miles, a coastal state can claim the seabed and its subsoil up to 350 nautical miles (650km), such as South Africa does.

Then there are the high seas: How does the law limit the freedoms that all nations have on the high seas to ensure the sustainability of our fish populations? How do we apprehend people invading our territorial waters and EEZ from the high seas in order to illegally harvest our fish and marine resources?

"A lot of work is being done on this now with the use of technology such as drones, but many African states do not have the means to protect their waters, or to detect ships which are supposed to have GPS navigation [indicating] their position but take various steps to avoid detection," says Prof Vrancken whose research includes the legal developments that affect African coasts and the maritime environment, as well as incorporating the international law of the sea into the domestic legal system of African states and into South African law.

Last year, Prof Vrancken edited the first edition of a new journal *iilwandle zethu: The Journal of Ocean Law and Governance in Africa* (the title meaning "our sea" in Xhosa) and he produced an update of *The South African Ports Law Handbook* with Nelson Mandela University doctoral student Zintle Sivisa-Thompson.

Also last year, he co-authored an 800-page book being published by Juta in November 2017, titled: *The Law of the Sea: The African Union and its Member States*. It has more than 20 authors and is the first attempt at a systematic reference work on the law of the sea in Africa.

Commenting on South Africa's new Marine Spatial Planning Bill, which was tabled in parliament earlier this year, Prof Vrancken said: "You need to understand

international law in order to develop marine spatial planning laws."

He has since been working with the Chair on Marine Spatial Planning at Nelson Mandela University, which is recommending to parliament several critical legal improvements to the current Bill before it becomes an Act.

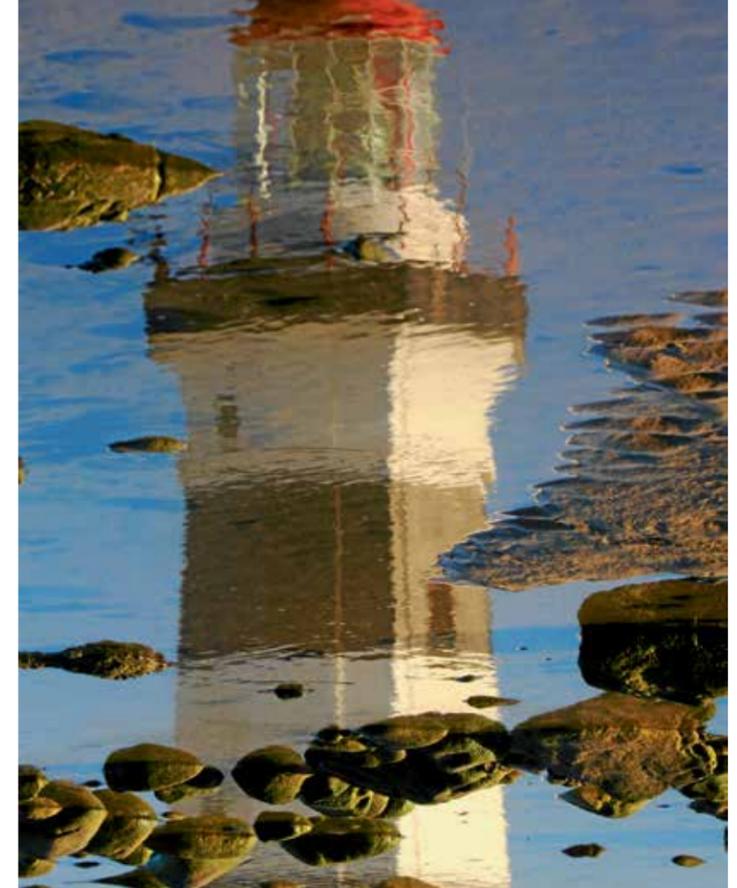
Prof Vrancken, who was the deputy leader of the marine protection services and ocean governance lab at the Operation Phakisa ocean labs in Durban in 2014, is also a member of the International Law Association's Committee on International Law and Sea Level Rise, and last year, he organised and chaired the law of the sea session at the Biennial Conference of the International Law Association, held in Sandton. It was the first time the conference has been hosted in sub-Saharan Africa.

"With global warming (and ocean levels rising), some island states might have their land territory disappearing. Current international law says if the islands disappear, that island state loses one of the basic elements that define a state. But what about the people with the nationality of that state, Where do they go? And does that island state also lose its EEZ and its resources? We have to relook at all these issues as the ocean levels rise. Part of this is to legally examine who is responsible for the islands disappearing, the island state or the major economies fuelling global warming."

Another pressing legal issue the Chair is researching is the protection of genetic resources at sea. Doctoral student Tanya Wagenaar is researching this.

"It brings us to a completely different idea potentially of how life is created and pharmaceutical companies are spending billions of dollars collecting and analysing specimens from (the sea)," says Prof Vrancken.

"But to whom do these organisms belong and if a cure is developed from one or more of them, does the organism and cure belong to the company that has the resources to find it or somebody else? These are some of the complex laws we are addressing as the world fixes its focus on the oceans."



All eyes on the sea: three key focus areas

The South African Research Chair Initiative (SARChI) Chair of the Law of the Sea and Development in Africa focuses on three areas:

- South Africa and the law of the sea, including the legal regime governing the South African continental shelf and the exploitation of its resources;
- Development in Africa and the law of the sea, including relevant indigenous law, and research at an international and comparative level on:
 - 1 The East coast of Africa and the Indian Ocean;
 - 2 The West coast of Africa and the Atlantic Ocean;
 - 3 The Southern Ocean and Antarctica; and
- The legal aspects of marine tourism.

Pirates, turtles and cruise ships: An array of postgraduate research

During 2016, the SARChI Law of the Sea Chair had 10 PhD and five Master's students working on marine projects in the following areas:

- Labour rights of fishers in Namibia;
- Maritime piracy legislation for Nigeria;
- Marine scientific research in Antarctica;
- Legal aspects of marine spatial planning;
- Legal regulation of surfing in South Africa;
- The Common Exclusive Maritime Zone of Africa;
- Protection of copyright aboard cruise ships at sea;
- Decommissioning of offshore installations on high seas;
- The safety of navigation and the role of port state jurisdiction;
- The intellectual property consequences of marine bioprospecting;
- African traditional fishers in the law of the sea and human rights law;
- The legal framework of concession agreements relating to Nigerian ports;
- The role and efficiency of international conservation instruments for turtles and turtle habitats; and
- Sustainable strategies for improved implementation of South Africa's marine living resources legislation.

The complicated task of ocean zoning

THE ocean is a busy place. Apart from the sea life inhabiting its countless ecosystems, it plays host to commercial fisheries, ship traffic, gas exploration and seabed-mining companies, fish farms, marine tourism, marine protected areas and much more.

Dividing the ocean into “zones” for its various uses – which are likely to increase with the government’s push to develop the country’s blue economy through Operation Phakisa – is the work of marine spatial planners. They are essentially the town planners of the sea.

“Trying to zone any human activity in the sea is very complicated,” says Prof Mandy Lombard, who holds a Research Chair in Marine Spatial Planning at Nelson Mandela University.

Marine spatial planning is a highly specialised field, because it has to take into account all the ecosystem activities that take place in three-dimensional ocean space, from the bottom of the ocean through the water column to the surface. In addition, different areas of the sea – from the high water mark on the shore to the deep blue yonder – fall under the jurisdiction of different legislation, national closer to the shore and international, the further out one goes – adding complicated legalities to the zoning process.

The Chair is playing a key role in commenting on and helping to improve the draft Marine Spatial Planning Bill released in 2016, the aim of which is to achieve better regulation of the ocean space.

Prof Lombard explains that the Bill is highly complex as there is all sorts of existing legislation, such as for fisheries, Marine Protected Areas (MPAs) and some oil and gas legislation, but the legislation doesn’t converge and this is what the draft Marine Spatial Planning Bill is supposed to do.

To understand the complex legislation she is collaborating with the leading legal specialist on the law of the sea in South Africa, Professor Patrick Vrancken, who



holds the SARChI Chair on the Law of the Sea and Development in Africa at Nelson Mandela University. The two Chairs are working closely, recommending to parliament several critical legal improvements to the current Bill before it becomes an Act.

Lombard and her team of postgraduate students have also made recommendations for the Bill relating to marine conservation strategies and adaptive management approaches, based on their research, which is underpinned by a healthy-ecosystems approach.

Lombard said marine spatial planning had two essential flavours: one was economy-driven, and the other was ecosystem-driven.

“The latter is the view I take, and that most scientists take. One of my principle roles in this Chair is to demonstrate that ecosystem security underpins everything we get from the ocean. All our research is based on healthy functioning ecosystems ... Let’s take care of ecosystems first, and then see if we can do all the other things.”

Lombard said the management of South Africa’s coastline was currently a divided field, with different specialists and stakeholders concentrating on their own respective areas of interest, rather than how they fit into the bigger picture.

“There is lots of disconnect. What we are pushing for is integrated ocean management, where all the different stakeholders – from those

involved in marine spatial planning to fisheries management to policy makers – can sit around the same table and talk about their different interests, to make the best decisions about managing South Africa’s ocean space.”

She said the different research and legislation could then feed into an Integrated Oceans Act, similar in purpose to the existing Integrated Coastal Management Act.

The nine students conducting research under the Chair all focus on projects that demonstrate the value of functioning ecosystem services to the planning process. Their projects range from research on whales and other marine top



Prof Mandy Lombard has been working hard for many years, to design strategically-placed marine protected areas for this country.

predator species to identifying and mapping key fishing areas within exclusive economic zones.

For many years, Lombard and other researchers have been working hard to design strategically placed marine protected areas for South Africa. With the arrival of Operation Phakisa, many of these protected areas have been gazetted for comment.

“The good thing is that Phakisa has allowed us to take a lot of steps forward. However, at the same time, government is pushing to unlock the ocean’s economy – the ‘blue’ economy – and we need proper legal instruments in place to guide this process, and help us understand the trade-offs involved in allocating ocean space to one activity versus another.”

Lombard, who has a PhD in animal physiology (specialising in sea birds) from the University of Cape Town, has been working on systematic conservation planning since 1991, initially focusing on land and shifting to marine in 2004.

She completed post-doctoral work in the United States and Australia, and also worked for UCT’s Fitzpatrick Institute of African Ornithology.

She has been an independent research consultant in conservation planning since moving from Cape Town to Sedgfield in 1998, and has published papers through Nelson Mandela University. What drives her research is “a longstanding and deep love for the ocean”.

It’s about working together to fast-track SA’s blue economy



Nelson Mandela Bay is destined to play a lead role in developing the untapped potential of the blue economy without it negatively impacting on the country’s ecological sustainability.

“NATIONAL government has formally recognised Nelson Mandela University as the leading South African university in the marine and maritime fields. Ocean sciences research, training and innovation across numerous disciplines at our university, several of which are already well established, will play a pivotal role in the growth of the ocean economy and Operation Phakisa,” says Judge Ronnie Pillay, the university’s Chair of Council.

Operation Phakisa is the fast-track development plan, launched by the South African government in 2014. Its oceans economy project includes six key areas, namely:

- Marine transport and manufacturing;
- Aquaculture;
- Offshore oil and gas;
- Marine protection and ocean governance;

- Small harbours and coastal property development; and
- Coastal and marine tourism.

Through Operation Phakisa, the South African government plans to use the potential of the oceans economy to address the challenges of poverty, unemployment and inequality. The ocean covers 70% of the earth’s surface and is an important source of food, energy and minerals.

“An analysis of South Africa’s oceans economy estimates that the ocean has the potential to contribute an estimated R177 billion to the country’s GDP, while creating up to one million new jobs by 2033, explains Nelson Mandela University’s Senior Director of Institutional Planning, Prof Heather Nel, a key driver in the university’s Ocean Sciences Campus.

“These potential growth

levers reflect at least 4% annual growth in both GDP contribution and job creation. Such ambitious targets cannot be realised without increasing the pool of skills available to the maritime industry.

“Qualifications are needed for a wide range of marine and maritime sectors and South Africa can learn from leading maritime nations such as our partners in the United Kingdom, Finland and Norway with its blue growth for a green future strategy.

This strategy incentivises the establishment of local, regional, continental and global marine and maritime clusters.

Through these clusters, marine and maritime industry experience is linked with research-based knowledge from universities to stimulate innovation for the benefit of the blue economy.”

Growth plans

Plans to grow the maritime economy depend on the availability of skilled people to implement them, along with the generation of knowledge and technological innovation to support a globally competitive maritime industry.

The South African International Maritime Institute (SAIMI) was established in response to that need, as a national institute to coordinate and facilitate skills development to support the growth of the oceans economy.

“SAIMI plays a linking role between industry, education and training institutions and government. Our role is to help identify industry needs and opportunities, and facilitate the development of education and training programmes to meet those needs,” says SAIMI chief executive



Bringing shipbuilding and marine engineering to Nelson Mandela Bay

WITH all eyes focused on South Africa's blue economy, there is an overriding need to develop skills for the marine and maritime industry – which includes boosting the country's shipbuilding capabilities.

Nelson Mandela University's Faculty of Engineering, the Built Environment and Information Technology (EBEIT) is determined to drive development in this area.

Not only do its expanded facilities include training space for shipbuilding, but it is also offering new qualifications in the industry, including a degree in Marine Engineering from 2018 and one in Nautical Science from 2020.

The faculty has received much support for its marine and maritime focus, including funding from the manufacturing, engineering and related services SETA (merSETA) of R10 million a year for three years, starting in 2016.

"The new degrees and the association with merSETA will significantly contribute to the maritime future of the Eastern Cape and South Africa. Our approach is also aligned with the Nelson Mandela Bay Metro's request that Operation Phakisa invest in a shipbuilding sector in Port Elizabeth," says Karl du Preez, merSETA Chair in Engineering Development at the university.

The faculty's exponential marine and maritime expansion over 2016/17 coincides with the completion of additional infrastructure, which includes two training studios for shipbuilding and high definition video conferencing facilities. The combination of contact and live video lectures combined with practical instruction offers EBEIT students access to world-best education.

"EBEIT intends to play a significant role in the development of Port Elizabeth as a manufacturing hub for marine vessels of all sizes," says EBEIT's Executive Dean, Dr Oswald Franks.



Nelson Mandela University's Faculty of Engineering, the Built Environment and Information Technology (EBEIT) is determined to play a significant role in the development of Port Elizabeth as a manufacturing hub for marine vessels of all sizes.

Photograph: Greg Davids



Greg Davids, a prominent figure in the marine manufacturing sector, is CEO of the Urban Soul Group, which includes USG Advisory Services, the organisation that represents Finnish corporation Wärtsilä - one of EBEIT's key industry partners - in South Africa.

Part of the funding from merSETA is being used to hire experts in Marine Engineering to teach, support and grow students for the marine and maritime industry and to increase research for naval architecture and ship engineering.

"Drawing on our significant base knowledge in Mechanical and Electrical Engineering, we have registered the new Bachelor of Engineering Technology: Marine Engineering, which will be offered at Nelson Mandela University from 2018," says EBEIT's Marine Engineering and Nautical Science Project Manager, Howard Theunissen. This unique qualification in South Africa has been endorsed and approved by the Engineering Council of South Africa (ECSA) and the SA Maritime Safety Authority.

From 2020, another new degree will be offered by EBEIT, the Bachelor of Nautical Science, to train ship captains and ship navigators. It is being designed in collaboration with Captain Richard Dunham from the Australian Maritime College (AMC) in Tasmania.

One of EBEIT's key industry partners is the Finnish corporation Wärtsilä, which manufactures and services engines for about 40% of all ships worldwide, in addition to a range of equipment in the marine and

energy industry. The company routinely trains engineers and technicians from all over the world.

Wärtsilä recently won the tender to supply the engines and power train for the South African Navy's new hydrographic vessel – a scientific research and investigation vessel that uses sound and visual detection to determine what is happening under the sea. It is being built by the Southern African Shipyards in Durban and the contract requires Wärtsilä to engage in development activities, which they are bringing to the university where they will establish a Wärtsilä /Nelson Mandela University Land and Sea Academy.

As part of this, Wärtsilä is donating Wärtsilä engines, a 2-speed gearbox, thruster and propeller, as well as a range of cutting-edge simulation and software packages for the training of technicians and marine engineers who work on ship power systems.

Wärtsilä is represented in South Africa by USG Advisory Services, a division of the Urban Soul Group whose CEO, Greg Davids, is a prominent figure in the marine manufacturing sector. He has extensive experience and longstanding partnerships in the international and South African shipbuilding and repair industries, and among vessel owners and fleet managers as well as the fishing

sector. Last year, EBEIT appointed Davids as an Adjunct Professor.

Other lecturers and specialists recently contracted by EBEIT include Finnish naval architect Hakan Enlund, who has extensive ship building experience, including the construction of a number of South African navy vessels, such as Agulhas I and II; John Fernandes, who is currently doing his PhD in Mechatronics with a maritime focus on intelligent navigation of mobile systems for unmanned vehicle applications, such as the loading of cargo vessels or the use of submarines to inspect undersea pipelines or unmanned sea vehicles to inspect the surface of the sea; Port Elizabeth-based Chief Engineer Sergio Giannotti, who has 15 years of practical ocean-going experience; and Boswell Douse, who is completing his Master's in Naval Architecture at the University of Southampton, the leading marine and maritime university in the United Kingdom.

Adding to EBEIT's applied Marine Engineering skills is the Advanced Mechatronics Technology Centre at the university, which has received support from MerSETA to develop its capabilities in process control in the marine industry – such as controlling ship rudders, heating and cooling systems, and the integration and visualisation of systems, many of which are remotely controlled.

Prof Malek Pourzanjani.

Established in 2014, the successes of SAIMI to date include:

- Managing the National Cadet Programme, which is supporting over 200 aspirant professional mariners;
- Forging new partnerships to expand the training of sea-faring cadets, as well as new programmes in other areas of the maritime sector;
- Coordinating the Operation Phakisa Skills Working Groups whose work will lead to a national maritime skills framework;
- Facilitating the development of the Research, Innovation and Knowledge Management Roadmap for the maritime sector; and
- Securing a three-year grant from the National Skills Fund to establish SAIMI, to ensure the continuity of the National Cadet Programme, and develop new programmes

SAIMI is hosted at Nelson Mandela University.

What is SAIMI?

The South African International Maritime Institute (SAIMI) is facilitating the development of the skills and knowledge base required to ensure the success of "blue economy" maritime development initiatives such as Operation Phakisa and the African Union's African Integrated Maritime Strategy.

It is a multi-disciplinary, multi-stakeholder institute active in all aspects of the maritime field, including shipping, harbours, manufacturing and construction, sustainability, environment, law, and marine tourism. SAIMI also links with industry and academia in marine and coastal sciences and works closely with existing education institutions offering post-school maritime courses.

The Institute facilitates input from the industry to ensure that the necessary job-related skills and training are being offered.

SAIMI and Operation Phakisa

SAIMI is a direct outcome of Operation Phakisa, the South African government's initiative to unlock the potential of the oceans to generate socio-economic value and employment – estimated at up to R177 billion added to Gross Domestic Product (GDP) and a million jobs by 2033.

Successes reported by the government by the first quarter of 2017 include the unlocking of R7,323 billion in investments into the Oceans Economy and the creation of over 6,900 jobs.

Operation Phakisa and its forerunners – a maritime skills study, summit and feasibility study commissioned by SA Maritime Safety Authority and government partners between 2011 and 2013 – identified the need for a dedicated institute to coordinate and improve the provision of maritime education, training and skills development.

Plans to grow the maritime

economy depend on the availability of skilled people to implement them, along with the generation of knowledge and technological innovation that looks to the future. SAIMI is the outcome of that identified need, and is facilitating a number of skills development initiatives to support the realisation of Operation Phakisa objectives.

It is estimated that the oceans lapping the 3,900 km South African coastline (including the Prince Edward Islands) have the potential to contribute substantially. In fact, these growth levers reflect at least 4% annual growth in both GDP contribution and job creation.

Based in Nelson Mandela Bay – the only city in South Africa with two commercial ports – SAIMI is uniquely positioned to stimulate and coordinate the research, education and skills development needed to position South Africa as a global leader in the sustainable utilisation of maritime resources.



Dr Oswald Franks, Executive Dean of the Faculty of Engineering, the Built Environment and Information Technology (EBEIT), is looking forward to Port Elizabeth's development as a manufacturing hub for marine vessels of all sizes.



Prof Janine Adams heads up the Institute for Coastal and Marine Research (CMR) - which is the largest institute in the new Ocean Sciences Campus.

40 years of coastal and marine research

NELSON Mandela University's transdisciplinary Institute for Coastal and Marine Research (CMR) – which was launched last year and is the culmination of 40 years of coastal and marine research at the university – will be the largest institute in the university's Ocean Sciences Campus.

"We have over 160 researchers and four South African Research Chairs in the CMR, which will be based at the new Ocean Sciences Campus," says CMR Director Prof Janine Adams (above), a professor in the Botany Department, specialising in estuaries.

"The new Ocean Sciences Campus will provide a multi- and transdisciplinary space where

we can interact and explore collaborative opportunities across faculties and with our national and international partners."

Prof Adams says an important part of their work is to generate interest amongst researchers and students across faculties to focus on the marine and maritime environment. "We are also engaging with government, learners and citizens about Ocean Sciences."

Last year, Prof Adams co-edited a special issue in the South African Journal of Botany on the biodiversity and ecology of estuaries.

"Estuary health, conservation and management is critical because they are the meeting place of

land and sea, nurseries for many important marine species including linefish, zones of economic activity for coastal cities and towns, such as for fishing, and buffers against sea level rise and coastal erosion."

"One of our PhD candidates, Gerhard Cilliers, who is a resource manager from the DWS, has put together an estuary-monitoring programme for South Africa that is now implemented in over 20 areas."

It is a good example of the link between science, policy and management the CMR encourages. The CMR draws on many areas of its research to inform policy and to transfer knowledge and expertise through training programmes to various government departments.



A school of dolphins swims along Port Elizabeth's Algoa Bay coastline. Photograph: Dr Th. Bouveroux, CMR

Whales and dolphins - flagships of ocean health

ALGOA Bay has a great diversity of marine life, including unusually large groups of bottlenose dolphins. While many marvel at this beauty, Dr Stephanie Plön, a dolphin and whale (cetacean) specialist with the Earth Stewardship Science Research Institute at Nelson Mandela University, is interested in what these creatures can tell us about the state of our oceans.

Dr Plön explains that Algoa Bay and the Eastern Cape are ideal settings for research on dolphins and whales for a number of reasons, including the presence of about half of the world's recognised cetacean species, and the marine mammal research collection at the Port Elizabeth Museum, which is believed to be the largest in the southern hemisphere and the third largest in the world. It is a fascinating, invaluable resource for marine scientists worldwide.

"Our dolphin and whale species are not only important in their own right; they are key indicator species for overall ocean health because they are at the top of the marine food chain. Research on them informs the decisions and actions required to sustainably conserve our oceans and marine species," says Dr Plön, who has researched the Eastern Cape Coast and Algoa Bay's dolphins, whales and marine

environment since 1995.

Over the past seven years, Dr Plön and her team have also been researching the pathology of stranded dolphins and comparing them to the dolphins caught in the KwaZulu-Natal shark nets.

"We know that strandings are in most instances a result of the animal being sick, whereas the by-catch animals should be reflective of the normal, wild population. The pathology investigation therefore significantly assists us in assessing the general health of South Africa's oceans."

Since 2009, parasite lesions have been detected in a number of different dolphin species, and both in the stranded animals as well as those caught in the shark nets. The specific parasite is yet to be identified, but marine parasites are increasingly being linked with ocean pollution.

Human impact

PhD student Renee Koper is examining the potential impact of shipping noise on baleen whale mother-calf pairs, particularly in relation to Coega's deep-water port.

Baleen whales are adversely affected by the "masking effect" of low-frequency noise from shipping, which blocks out the

whales' acoustic calls. She is researching how this affects cow-calf pairs, as it is not yet known whether they communicate vocally or by touching or both. Increasing human impact on the marine environment could potentially have an adverse effect on whale calves bonding with their mothers.

Sightings

Master's student Titus Shaanika is interested to see if he re-sights individual dolphins (which may be resident in Algoa Bay) or if they are only seen once and are therefore simply passing through the bay.

A population size estimate from research done in the mid-1990s has indicated that Algoa Bay may house a population of up to 28,000 bottlenose dolphins, but minimal research has been done on these animals since. "We know little about whether these dolphins simply pass through the bay or whether they visit frequently or even may be resident," says Dr Plön.

This knowledge is important in order to monitor populations, and while there is currently little concern about bottlenose dolphin populations in Eastern Cape waters, the population of Indian Ocean humpback dolphins (*Sousa plumbea*) in Algoa Bay has rapidly

declined in recent years, leading to the species being declared as "Endangered" in South African waters.

Many factors may influence whether a population can be considered "healthy" or whether managers and conservationists need to be concerned. For example, previous research conducted by Dr Plön and her students indicated that the sardine run has changed substantially over the past 30+ years and, as a result, the diet of the main dolphin species associated with the sardine run, the long-beaked common dolphin *Delphinus capensis*, has also changed.

"The warming in ocean temperatures has meant that the sardines either go deeper or migrate further offshore as they like cooler water, rendering them less available to predators like dolphins," explains Dr Plön.

"Stomach content analysis revealed that previously, the common dolphin's main diet during the sardine run consisted of sardine, but since the late 90s this has changed to mackerel."

However, indicators of nutrition and body condition have not changed over the time period, suggesting that the change in diet is so far not impacting the dolphin population adversely.

SARChI Chairs in the Institute for Coastal and Marine Research

SARChI: Shallow Water Ecosystems
Professor Renzo Perissinotto

SARChI: Law of the Sea
Professor Patrick Vrancken

SARChI: Marine Spatial Planning
Professor Amanda Lombard

SARChI: Oceanography and Food Security
Professor Mike Roberts

Transdisciplinary research
Some of the transdisciplinary research areas at Nelson Mandela University include:

- Arts**
Political and Conflict Studies: The blue economy
Architecture: Regenerative architecture & ecosystem rehabilitation
- Business and Economic Sciences**
Development Studies: Marine socio-ecological systems, resource economics
- Engineering, the Built Environment and Information Technology**
Engineering: coastal infrastructure
- Health Sciences**
Emergency Medical Care: Diver Occupational Health & Safety
- Law**

Law: marine governance
Science
Botany, Zoology, Geosciences, Statistics, Chemistry, Oceanography, Sustainability Research Unit

National and International Partners

Numerous external partners both national and international include:

National
Close linkages with SAEON, Bayworld/BCRE, SAIAB, DEA: Oceans & Coasts, SANParks, SAIMI, CSIR, Ezemvelo KZN Wildlife, isiMangaliso Wetland Park, Nansen-Tutu Centre for Marine Environmental Research

International
Links exist with institutions in Norway, France, Sweden, United Kingdom

Engagement beneficiaries

- Local government: Nelson Mandela Metro, Kouga, eThekweni;
- Provincial government: DEDEA, Western Cape;
- National government: DEA, DW&S, DAFF;
- International: Ramsar, Nairobi and Abidjan Conventions;
- Conservation authorities: SANParks, CapeNature, Eastern Cape Parks, Ezemvelo KZN Wildlife; and
- Public, Learners.

Research Diving Unit

The Research Diving Unit (RDU) is consolidating its operations under the Institute for Coastal and Marine Research (CMR) and will be housed on the new Ocean Sciences Campus. Last year, the RDU conducted a total of 104 operational days facilitating subtidal and marine research, which equates to 2.1 diving operations per week for various research projects and service level agreements.

Research, training and consulting activities include:

Research
Research, particularly interdisciplinary research, is the primary activity of the Institute, grouped under three broad thematic areas with several projects spanning more than one theme:

Global change
This covers a range of projects aimed at monitoring and understanding change, both anthropogenic (caused or influenced by humans) and natural, and how this impacts coastal and marine systems and human communities dependent on them. It includes monitoring climate change; pollution monitoring; biodiversity loss; building socio-ecological resilience in light of global changes; and understanding risks and vulnerabilities due to environ-

mental change.

Living resources and food security
This covers projects studying and developing coastal and marine living resources, which are, or can be, utilised as food sources, with the emphasis on sustainability.

Biodiversity and conservation
This covers a wide range of projects broadly relating to understanding, protecting and managing coastal and marine ecosystems, both for conservation and for sustainable human use.

Training
Members provide research-based training through Master's and Doctoral programmes based in participating academic departments. The CMR offers short courses to train divers and courses on other topics on demand.

Consultancy
The CMR embraces a broad and unique spectrum of expertise relevant to coastal and marine issues through its members who are drawn from diverse disciplines. This pool of expertise, the broadest in the region, is used to provide community service in the form of commercial consultancies on issues in the coastal zone and marine environment, including environmental impact assessments, site inspections and specialist reports.

Ocean Sciences Growth Hub for Port Elizabeth



THE city of Port Elizabeth in Nelson Mandela Bay is extremely well positioned at the base of Africa to become a key South African port city.

Our goal is to create a marine and maritime growth hub here, in partnership with national government, industry and Nelson Mandela University – the most important resource and stakeholder in the city.

The city and the university are in the process of developing a much closer relationship, with integrated marine and maritime research and development projects. To achieve this, the city's Mayor, Athol Trollip, has already engaged extensively with Vice-Chancellor Prof Derrick Swartz.

As a metro, we are pursuing a cluster approach to our economic growth and development strategy – including automotive, agri-processing, tourism and maritime clusters – and are working with partners in major port cities in Germany, Spain, Scandinavia, the United Kingdom and the United States. We believe this cluster approach to economic development will help us to reap the full benefits of working in partnership with the university and industry towards shared objectives

This approach will not only attract people to invest and settle in Port Elizabeth, but will also serve to retain our university's graduates who too often migrate to other cities to pursue their careers.

To attract investment and

Councillor Andrew Whitfield, Head of the Portfolio for Economic Development, Tourism and Agriculture in the Nelson Mandela Bay Municipality, shares how unlocking the Bay's oceans economy potential can help to grow the city.

confidence, that we have to bring good governance and integrated planning to the table, and we are working hard to achieve this against the backdrop of the metro's poor governance over the last decade.

As the city's DA-led coalition municipality [elected in 2016], we are pleased to say that while we still have many challenges to overcome, we are in a much stronger financial position with notably improved good-governance indicators, in terms of cutting red tape, dealing with corruption and facilitating trade and investment.

Tourism is a key cluster for the city and we need to make sure that ocean health is prioritised and not overlooked for other blue economy pursuits, such as oil and gas, and offshore bunkering [refuelling of ships]. In 2016, Nelson Mandela Bay saw the arrival of eight million domestic tourists and 249,000 international visitors. The tourism sector is responsible for about 50,000 jobs and has tremendous growth potential.

Our incredible coast, beaches and Big Five malaria-free game reserves, attract people here. But at present, they don't stay long enough

and we are working to change this. For example, we are now actively marketing ourselves as the dolphin capital of the world, and we look forward to the imminent issuing of whale-watching licences, to bring visitors closer to our ocean wildlife. We will also proactively market ourselves as the national and international conferencing destination of choice for the marine and maritime sector, the blue economy and Operation Phakisa.

The waterfront development will further increase our tourism numbers; our goal is to redevelop the industrial port areas into a working port combined with living, leisure and lifestyle developments. The tender has been awarded for the dismantling and removal of the fuel tanks.

As the municipality, we are the custodians of the city and have a significant role to play across all sectors – from new business development to public health, which includes river, estuary and ocean health.

I believe the future of the global economy is going to be more prominently driven by cities as the engines of growth. It is therefore important that the decision-making

powers of cities be unlocked by national government and key national parastatals, such as Transnet, which is the Port Authority. We have invited Transnet to partner with us and have initiated a port forum on how we can work more closely with Transnet in the development of our port city, harbour, waterfront area and blue economy.

We need to bring everyone on board on this new journey – and we welcome investment delegations. In time, we will build a team to work on unlocking the oceans economy potential, working with marine and maritime specialists, Nelson Mandela University, Transnet, the Deepwater Port of Ngqura and Coega Development Corporation, and the Nelson Mandela Bay Development Agency (the driving force behind urban regeneration in the Metro).

From our anchor automotive industry, to eMobility innovations and ship-building, to our marine and terrestrial wildlife offerings, and our outstanding hospitality offerings, conferences and sporting events, including the Ironman 70.3 World Championships in September 2018, we have identified ourselves as an iconic, friendly ocean city. Together with our partners, we will be going all out to establish ourselves as the ocean sciences, blue economy and tourism destination of choice.

Councillor Andrew Whitfield
E: awhitfield@mandelametro.gov.za



Primary school learners and the neighbouring community are benefiting from an aquaponics unit at Nelson Mandela University's Missionvale Campus.

Aquaponics yields fresh fish, produce - and partnerships

A NEW aquaponics unit at Nelson Mandela University's Missionvale Campus is an excellent example of institutional collaboration and partnerships that benefit others.

The new unit, alongside the medicinal garden, will see ongoing interaction between Agriculture, Game Ranch Management, Human Movement Science, Dietetics and Nursing Sciences students involved in implementing an innovative and cost-effective food production hub and support services.

Aquaponics is an innovative,

intensive and inexpensive food production technique that brings together aquaculture (fish farming) and hydroponics (soilless crop production) in a closed system that dramatically conserves water (using 90% less water than traditional planting methods), and yields abundant and marketable fresh produce and fish.

Working with partners INMED South Africa (an NPO helping vulnerable children) and Mondelez South Africa, the aquaponics unit forms part of a broader Health in

Action programme launched in 2015 to promote healthy lifestyles, address obesity and alleviate hunger among primary school children. As many as 70 primary schools will benefit from the project that was launched last year.

Using a holistic and integrated approach, the project has seen Nelson Mandela University's Human Movement Science students assist with training unemployed and out-of-school youth to become school-based break-time buddies.

The Dietetics students are

involved with studies on the salt and sugar intake of primary school children and its effect on health, while Nursing Sciences students take the blood pressure of these youngsters. All these projects are run in collaboration with INMED South Africa.

An MTech student, Mpendulo Ngcakani, is managing the aquaponics system as part of his postgraduate research, which is based on examining factors affecting the viability of aquaponics in the Nelson Mandela Bay region.

Nelson Mandela University graduate Yonwaba Sipeliti, a full-time member of Nelson Mandela Bay's Learn to Swim programme, gives free swimming lessons to children from underprivileged backgrounds.

Future ocean sciences students need to learn to swim

"If you learn to swim as a child and are comfortable in water, you can later pursue a career in the marine and maritime."

SO says Nelson Mandela University graduate Yonwaba Sipeliti who is teaching children from poorly resourced areas to swim.

"It's a big thing for children to climb into a swimming pool for the first time. The moment the water is above their chests they either feel as if it is going to swallow them or they jump in and risk drowning," says Sipeliti (30), a full-time member of Nelson Mandela Bay's *Learn to Swim* programme.

He teaches children from the age of nine years to swim at eight public swimming pools in the inner city, townships and northern areas of Nelson Mandela Bay, as well as at the swimming pool at Nelson Mandela University. The lessons are free.

His goal is to grow it into a national model that is included in the curriculum for all primary schools. The programme already runs in several provinces through their respective swimming federations. In Nelson Mandela Bay, it is part of Nelson Mandela Bay Aquatics (NMBA), affiliated to Eastern Cape Aquatics and Swimming South Africa.

Sipeliti has been nominated for The Herald Citizen of the Year award for the contribution he makes to the safety of local communities, especially his efforts to curb

drownings.

"Water covers over 70% of the Earth's surface and the ability to swim is a wonderful experience. It can also save your life and it expands young people's future career horizons," explains Sipeliti.

"Nelson Mandela University offers all young people with academic potential the opportunity to pursue marine and maritime studies through its new Ocean Sciences Campus. Anyone who cannot swim will never feel comfortable about pursuing an ocean-related career.

"The other important aspect of educating children and all people to understand and enjoy water, freshwater and seawater, is that it makes it easier to explain about ecosystem conservation and to get our anti-pollution message across.

"I have a team working with me and we first do water safety in the schools and then offer free swimming lessons from Grade 4. We focus on 9-, 10- and 11-year-olds, as most drownings are in that age group, with children running and jumping into water without understanding the consequences."

It's a joyful experience to watch Sipeliti teaching children to swim, and witnessing their love of water developing. "Their first experience of being in the water must be really

positive; they must feel the pleasure of moving freely in water," he explains.

The freedom of movement in water has been a magnet for Sipeliti since he was a child growing up in a rural community near Ngcobo in the Eastern Cape.

"I have been in love with water since I was a very small boy. I would go and swim in the dam at every opportunity ... I didn't know how to swim, I simply imitated people I saw swimming, including on TV. Then when my older brother came to Nelson Mandela University to do his BCom, I visited him and I would watch people swimming at the university. The coach was Elizabeth 'Bitty' Joubert and I asked her to teach me, which she did. Twenty years later I'm committed to a swimming career and she is on the Board of *Learn to Swim*."

Sipeliti also teaches children and adults to swim in the sea, and is a lifeguard on Port Elizabeth's Hobbie Beach.

"Most children love water and our goal is to make sure that as many children as possible throughout South Africa learn to swim properly from a young age. If I can get the *Learn to Swim* programme included in the primary school curriculum then I have achieved my current life goal."

Research Diving Unit

Nelson Mandela University wants to ensure that all students, postgraduates and researchers pursuing marine, maritime and related disciplines are able to swim competently, and to benefit from the exceptional Research Diving Unit (RDU), which is part of the Institute for Coastal and Marine Research (CMR) on the Ocean Sciences Campus.

On average, the RDU operates on just over 100 dive days per year, which equates to two diving operations per week. Class 4 commercial diver and supervisor training, and Class 5 scientific diver training courses and upgrades are offered.

At the RDU location on campus, a new Hyperbaric Chamber is being installed through the South African Environmental Observation Network-Department of Science and Technology (SAEON-DST) partnership.

A diving medical emergency service provider services the RDU to meet the requirements of the Occupational Health & Safety Act and Diving Regulations.

The unit also supports the Emergency Medical Care (EMC) Department by providing practical crew training for the paramedic students for their water rescue module.

Harnessing the potential of our oceans for a sustainable future

THE ocean covers 70% of the Earth's surface and holds 97% of the planet's water. The world's oceans regulate global climate systems that make the Earth habitable for humankind and produce more than half of the oxygen in the atmosphere. About half of the world's population lives within the coastal zone and ocean-based businesses contribute more than \$500 billion to the world's economy.

Given the significance of the oceans for sustaining life on the planet, globally renowned oceanographer and explorer, Sylvia Earle, asserts that: "We need to respect the oceans and take care of them as if our lives depended on it. Because they do." Inclusive economic growth, social inclusion and environmental protection are vital, interconnected prerequisites for a sustainable future. The United Nations Sustainable Development Goals (SDGs), adopted by world leaders in September 2015, foreground efforts to end all forms of poverty and inequality, while tackling climate change and protecting global oceans, seas and marine resources.

As part of the National Development Plan, the South African government aims to harness the economic potential of the country's oceans to address the triple challenge of poverty, unemployment and inequality by 2030. South Africa is bordered by the ocean on three sides and its coastline is about 3 924 km long and is located along one of the busiest international shipping trade routes in the world. South Africa's coastal waters support thousands of jobs and contribute millions of rand to the national economy each year, with coastal goods and services estimated to contribute 35% to South Africa's gross domestic product (GDP).

Operation Phakisa was embarked upon in 2014 through a collaborative partnership between government, industry, academia and civil society. *Phakisa* means, "hurry up" in Sesotho and it is a planning methodology adapted from Malaysia's Big Fast Results

approach to highlight the urgency of delivery. Through Operation Phakisa, detailed plans are informing strategy implementation to stimulate growth across various spheres of the oceans economy, namely: marine transport and manufacturing; aquaculture; offshore oil and gas; marine protection and ocean governance; small harbour development; and marine and coastal tourism.

A common thread running through all Operation Phakisa initiatives is the need to expand the pool of skills available to marine and maritime industries. This requires devoting particular attention to issues such as:

- Cultivating learner interest in ocean sciences through a comprehensive career advising strategy from basic to higher education levels.
- Improving the capacity at technical and vocational education and training (TVET) colleges and universities to expand their ocean sciences programme offerings.
- Promoting closer cooperation between educational providers and industry to improve the alignment between the available pool of skills and market demands.
- Stimulating growth in the oceans economy to reduce unemployment and improve the absorption of graduates into the labour market.

Basic education is important in fostering a national maritime consciousness in a country that has historically been terrestrial in its thinking. The Department of Basic Education has recognised this and is promoting maritime sector education at dedicated maritime high schools such as Lawhill Maritime Centre in the Western Cape and, more recently, the first maritime high schools in the Eastern Cape, George Randall and Ngwenyathi High Schools.

The post-school sector has also been gearing itself to respond to the skills and innovation requirements of the oceans



economy. TVET colleges produce artisan skills required for maritime manufacturing, as well as the vessel construction and repair industry. In addition, TVET colleges need to be more widely involved in maritime training beyond the basic production of artisans. To address this, there is an initiative underway to assist six colleges to pilot maritime training programmes for ratings and marine engineering.

Research shows that ocean sciences appear to exist in isolated pockets of excellence at selected universities. No single university in South Africa can claim to be a leading provider in responding to the wide-ranging skills development needs of the oceans economy.

The South African International Maritime Institute (SAIMI) was established in 2015 to support the goals of Operation Phakisa by facilitating a coordinated marine and maritime skills development, research and innovation plans that respond to industry needs. The institute will provide support to ensure that relevant qualifications and courses are developed and offered through partner public and private providers in close collaboration with industry. In this

way, maritime skills development, research and innovation will act as a catalyst for sustainable growth through the country's oceans.

South Africa can learn from leading maritime nations such as Norway with its strategy known as "blue growth for a green future". This strategy incentivises the establishment of local, regional and global maritime clusters. Maritime industry experience is linked with research-based knowledge from universities to stimulate innovation for the benefit of the oceans economy.

As a comprehensive university with the only dedicated ocean sciences campus in South Africa, Nelson Mandela University is well poised to become a university of choice in generating cutting-edge knowledge for a sustainable future, in particular as it relates to the grand challenges of our oceans.

As a coastal university, located in one of the world's only cities with two ports, Nelson Mandela University has a long history of involvement in ocean sciences and is actively cultivating emerging strengths in fields such as: marine engineering; naval architecture; renewable ocean energies; marine and coastal tourism; marine resource economics; shipping and port logistics; and marine spatial planning.

The university's ocean sciences campus will be a hub for creative, pioneering transdisciplinary, postgraduate ocean sciences research, teaching, innovation and engagement that will build, maintain and develop critical mass and strategic impact in key niche areas. The mission of the campus will span the three interdependent spheres of sustainability, namely, promoting sustainable livelihoods for coastal communities by tapping the economic potential of the oceans while preserving marine biodiversity and ecological integrity for the benefit of future generations.

Professor Heather Nel
Senior Director: Institutional Planning, Nelson Mandela University

Wide cross-section of qualifications

AN array of marine-focused qualifications at Nelson Mandela University gives students the opportunity to conduct practical research from the shoreline to estuaries to the ocean deep.

To meet the skill sets needed to grow the potential of the blue economy in a sustainable manner, Nelson Mandela University is

offering both undergraduate and postgraduate programmes across a wide range of disciplines.

It is also poised to introduce many more in line with national and international needs.

At present, the university offers postgraduate programmes in Maritime Studies, Oceanography, and the Law of the Sea, as well

as an array of short learning programmes specifically customised for executive leadership development within the marine and maritime sectors.

Building on what is currently in place, Nelson Mandela University plans to systematically introduce various new ocean sciences programmes over the next

few years, including:

- Marine engineering;
- Marine spatial planning;
- Maritime logistics, shipping and port management;
- Coastal, cruise and marine tourism;
- Nautical sciences;
- Naval architecture; and
- Marine resource economics.

Exciting new career opportunities

Thanduxolo Nkala is one of growing number of students who has chosen to pursue a qualification in the uncharted territory of law and the sea. We asked him why.

What degree do you have?

I have a Bachelor of Laws (LLB) degree.

What qualification are you pursuing now?

I am pursuing a Master's of Laws degree (LLM)

What is your area of research?

The research Master's I am doing is in the law of sea branch of public international law. The research focuses specifically on the legal regulation of marine scientific activity in Antarctica.

Why is your area of research so important?

The continent of Antarctica is not governed by any one sovereign government. It is governed through a multilateral system of governance comprising mainly the signatory States to the Antarctic Treaty of 1959. This treaty specifically consecrates Antarctica and its surrounding waters for the purposes of scientific investigation only. How this scientific investigation is regulated to preserve natural resources, among other things, becomes a critical question.

Why did you choose to study in the field of Ocean Sciences?

I actually started doing law of the sea related academic work in my undergraduate studies. In the final year of my LLB, I made the hard choice of doing a research treatise.

The treatise was on South Africa and its legal relationship with the Antarctica Treaty System. This area of focus was inspired by Prof Patrick Vrancken, my supervisor, who is the incumbent South African Research Chair in the Law of the Sea and Development in Africa. It was further inspired by the fact that there is a need for legal capacity for our country in respect of its Antarctic affairs. As a result, I had the privilege of being part of the South African government delegation to the 39th Antarctic Treaty Consultative Meeting in Chile, in 2016.

Tell us about your friends who are also studying in the field. Are they doing similar work?

I have two peers who are also doing with their Master's in the law of the sea field. They are focused primarily on law of the sea topics domestically. Racheal Chasakara is looking at the Marine Spatial Planning Bill, and Nathi Dwayi is looking at the jurisdiction of organs of state at sea.

We are all supervised by Prof Vrancken and have a hub-like network of LLB, LLM, LLD candidates, and post-doctoral fellows, doing law of the sea or ocean governance-related topics.

What's your take on the future of ocean sciences for the university, the metro, the country and continent?



Thanduxolo Nkala

I am both excited and cautious. The excitement comes with ocean sciences being a greenfields opportunity for our university, metro and country alike. It is even more exciting because of its transdisciplinary nature – the coming together of various academic disciplines in the institution to create our new campus. It is incredible and innovative. And, it's going to set Nelson Mandela University on a completely new trajectory of innovation, away from the "traditional" set-up of a university.

I am cautious because what all of these opportunities will mean for the ordinary South African – particularly, the poor and the marginalised. I think this is the question that should really preoccupy us, especially since our vision is to be a "dynamic African university". What will this mean for the ordinary African?

We need to constantly interrogate this as we go forward. There has been so much conversation around "the blue economy", which has provoked high levels of excitement throughout our nation. This is fine and well, but what does this mean for the ordinary South African?

We had high hopes of an economic shift with the 2010 Fifa World Cup. The beneficent opportunities largely went to the already privileged. What did it translate to for the ordinary South African?

Therefore, it will be important for us to critically think about how this new page can be written so that it does not repeat these patterns of privilege. It is difficult, but we have to think about it.

What is your advice to anyone who might be considering studying in this field?

From the law aspect, it is a difficult field because it is not readily available like your constitutional law or criminal law. The subject does not feature in most LLB curriculums, so there is no foundation from which to work. I would advise students to expose themselves to the fundamentals of the subject while still at undergraduate level.

But it is possible and very doable. If we can do it, so can any other like-minded student. And of course, this field offers great opportunities into the future.

The importance of working together

PARTNERSHIPS

As a means of advancing the scientific contribution to the oceans economy, Nelson Mandela University is working closely with an array of national and international partners.

As part of its strategy to develop a whole new range of maritime and marine education and training, research, innovation and engagement programmes to support Africa's blue economy working with a wide range of other universities, big business and conservation groups (as seen below).



INTERNATIONAL UNIVERSITIES

World Maritime University, Sweden
 Washington State University, USA
 Carl von Ossietzky University of Oldenburg, Germany
 University of North Carolina Wilmington, USA
 Universidade Federal do Rio Grande do Sul, Brazil
 Plymouth University, UK
 University of Southampton, UK
 University of Agder, Norway
 University of Tromsø – The Arctic University, Norway
 University of Bergen, Norway
 Satakunta University of Applied Sciences, Finland
 University of Gothenburg, Sweden
 University of Queensland, Australia
 University of Reunion, France
 Shanghai Maritime University
 Western Norway University of Applied Sciences
 University of Dar es Salaam, Tanzania

The university also has close working relations with other institutions of higher learning which have Ocean Sciences links in South Africa.

OTHER

UNESCO – Indian Ocean Expedition
 South African International Maritime Institute (SAIMI)
 South African Environmental Observation Network (SAEON)
 British Council
 British High Commission Pretoria – UK Science & Innovation network in South Africa
 Newton Fund
 National Research Foundation
 South African Management Industrial Association
 South African Coelacanth Ecosystem Programme
 French National Research Institute for Sustainable Development
 Institute of Marine Sciences, Tanzania
 Kenya Marine and Fisheries Research Institute
 Western Indian Ocean Marine Science Association
 National Oceanography Centre
 Council for Scientific and Industrial Research (CSIR)
 Department of Environmental Affairs (Oceans and Coasts)
 Department of Higher Education and Training (DHET)

Department for Public Works
 Department of Science and Technology
 Department of Agriculture, Forestry and Fisheries
 South African Institute for Aquatic Biodiversity (SAIAB)
 Nelson Mandela Bay Metro
 Nansen-Tutu Centre for Marine Environmental Research
 Coega Development Corporation
 South African National Parks (SANParks)
 Bayworld
 East Cape Development Corporation (ECDC)
 Wildlife and Environment Society of South Africa (WESSA)
 Nelson Mandela Bay Development Agency (MBDA)
 World Ocean Council
 Water Research Commission
 merSETA
 Wärsilä Marine Solutions
 CapeNature
 Department of Water Affairs and Sanitation
 South African National Biodiversity Institute
 Transnet National Ports Authority

NELSON MANDELA

UNIVERSITY



Nelson Mandela University's new Ocean Sciences campus will be a creative hub for pioneering and ground-breaking transdisciplinary, postgraduate Ocean Sciences research, teaching, innovation and engagement that puts us in a clear position to become the leading Ocean Sciences University in Africa.

Find out more: oceansciences.mandela.ac.za

E: postgrad@mandela.ac.za

Change the World

mandela.ac.za